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THE NEW SYDENHAM SOCIETY.

INSTITUTED MDCCCLVIII.

VOLUME LVIII.

A MANUAL

OF

PATHOLOGICAL HISTOLOGY

TO SERVE AS AN INTRODUCTION TO THE

STUDY OF MORBID ANATOMY.

BY

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VOLUME II. (WITH INDEX).

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THE NEW SYDENHAM SOCIETY,
LONDON.

MDCCCLXXIII.

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CORRIGENDA IN VOL. I.

Page 46, line 12 from top, *for* "efferent" *read* "afferent."

Page 48, line 9 from bottom, *introduce* "§ 51."

Page 188, line 10 from bottom, and throughout the whole of § 156, *for* "telengiectatic" *read* "telangiectatic."

Page 190, in head-line, *for* "carcinomatar" *read* "carcinomata."

Page 266, line 12 from bottom, and throughout § 232, *for* "telengiectasis" *read* "telangiectasis."

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VI.—MORBID ANATOMY OF THE LUNGS.

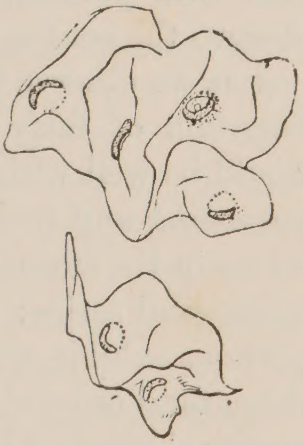
§ 405. All inquiries concerning the organs of respiration postulate a distinction between the AIR-PASSAGES on the one hand, and the PARENCHYMA on the other. This distinction is a thoroughly natural one, whether we regard the functional diversity of the parts, or the anatomical fact that the transition from the minuter bronchi to the infundibula is not gradual, but tolerably abrupt. Pathological histology has nothing to urge against it. Accordingly in proposing to discuss the pathological histology of the lungs in the ensuing chapter, we must be understood to refer exclusively to alterations in their parenchyma. The changes which take place in the mucous lining of the bronchi were dealt with by implication in the foregoing chapter; and although we shall often find it necessary to refer to certain morbid conditions of the bronchial tubes, which are causally related to changes in the pulmonary parenchyma, we shall either be dealing with conditions already familiar to the reader, or, if not, we shall take the opportunity of filling up whatever gaps may have been left in our knowledge by omissions made for the sake of convenience in the previous sections.

§ 406. Before subjecting the morbid alterations of the pulmonary parenchyma to a detailed analysis, we must touch on a problem of normal histology, whose solution is of the utmost importance to us, but which, notwithstanding numerous recent investigations, must still be considered open. The question is this: have the alveoli an epithelial lining, or have they not?

Since the due performance of the respiratory function depends entirely on the intimate contact of the blood contained in the capillaries with the atmospheric air, it would seem, from a physiological point of view, as though an epithelial lining would prove rather a hindrance than a help. This consideration must necessarily bias our judgment, so long as the anatomical evidence of the existence of an alveolar epithelium remains inadequate.

On the other hand, the development of the lungs, which corresponds at all points with that of other glands with ducts—beginning by an epithelial outgrowth from the mucous layer of the blastoderm—is in favour of the existence of an epithelial stratum; and the latest investigations of *Colberg* (Deutsch. Archiv für Klin. Medizin, ii. p. 453) prove conclusively that the alveolar epithelium of the human lung persists after birth. *Colberg* succeeded in demonstrating it in the lung of an infant nearly a year old, as a continuous layer of cells, giving an investment to the vessels also; these cells appeared spindle-shaped in transverse section, and could readily be detached from their bed *en masse*. To explain the uniformly negative character of the results obtained by examining the lung-tissue of adults, he lays stress on the fact, that in order to get sections of adequate thinness, every infundibulum, or some part of its constituent alveoli, must necessarily be cut through twice; consequently the epithelial lining, which is also twice divided, must form a segment of extreme fineness on the inner wall of the alveolus; and while the specimen is being removed from the razor-blade and transferred to the slide, this stands every chance of being dropped out and lost. The charge of actually blinding us to the presence of a constant element of the pulmonary texture, is a heavy one to bring against our methods of investigation; and happily it is not entirely borne out. It is quite possible to demonstrate the existence of an alveolar epithelium in any lung; though at first sight this epithelium resembles nothing less than a continuous stratum of cells; it does, however, represent the final and necessary product of that metamorphosis with whose earliest stages we have been made acquainted in the embryonic lung, and in the epithelial formation described by *Colberg* in the lung of the infant. The alveolar epithelium of an embryo at the fourth month is composed of distinct cells with large vesicular nuclei, cells which are at least as long as they are broad; they lie side by side with the regularity of a palisade, forming a continuous ribbon-like layer between the free surface on the one hand, and the capillaries on the other. In embryos of six months' growth, the alveolar lining may already be described as a single layer of pavement-epithelium. The cells are still distinct from one another, although their breadth much exceeds their depth. As the cells continue to grow flatter, they become fused together at their edges. In the lung of the mature fœtus we are no longer able to demonstrate the outlines of the individual cells by the silvering process. Still, even at the close of the first year after birth, a lamina, studded with fusiform enlargements and flattened nuclei, may still be detached from the alveoli in transverse sections. This can no longer be made out in the lungs of old people; but we find in the juice scraped from the pulmonary surface, as well as in the interior of the divided alveoli, certain gauzy, wrinkled shreds of extreme delicacy, which may elude the eye of even an experienced observer for a long time; for one does not easily recognise in the fine and seemingly disconnected lines, which are usually scattered over the greater part of the field, the outlines and plications of a membrane. They are dismissed as trifling inequalities of the slide or covering-glass, and yet, when once their connexion has been made out, nothing is easier than to find them again in any and every specimen, and to recognise them for what they really are. In these fine membranes, represented in fig. 125, the remains of nuclei may be demonstrated with the aid of carmine: these take the form of little, crescentic, highly refractive particles, disposed at regular intervals throughout the membrane. They form one side of an oval ring, whose other side is indicated only by a dotted line; the ring corresponds to the outline of the original vesicular nucleus, whose proper substance has shrunk into the insignificant crescent-shaped residue. We must beware, however, of regarding these cells as dead. We shall find, on the contrary, that these very nuclei, when exposed to irritation, increase in bulk, become surrounded with protoplasm, undergo division, &c. Briefly then, the inner wall of the infundibula and alveoli is lined by an exceedingly thin membrane, which may be shown to be the ultimate product of that flattening and coalescence of the pulmonary epithelia which begins at the very earliest period of life. Looked at from above, this membrane becomes invisible; even after staining the preparation with carmine, we can only discern the crescentic remains of

FIG. 125.



The normal alveolar epithelium of an adult's lung. Homogeneous membranes of extreme thinness, with rudimentary nuclei. $\frac{1}{500}$.

the nuclei lying in the interstices between the capillary loops; seen in profile, the epithelial membrane takes the form of a single sharp line, which passes uninterruptedly from one capillary loop to another, and lines the margins of the alveoli which appear between them. The membrane adheres closely enough to the subjacent tissues; it does not necessarily become detached when its nuclei resume their activity and separate as cells from the alveolar wall; nay, a partial separation is much more likely to be caused by simple serous transudation, as in œdema of the lungs; at least I have found the membranes in question peculiarly abundant in the fluid scraped from œdematous lung-tissue.

§ 407. Returning to our theme after this brief digression, we find ourselves confronted by a new difficulty; we have to establish a natural and at the same time practically useful classification of the diseases of the lungs. Here too we must revert to general principles.

The phenomena of disease are the normal vital manifestations of the organism under the influence of some unusual, hurtful or dangerous condition, which we term the morbific cause. An exhaustive knowledge of these causes would enable us to deal with pathology as a branch of exact physiology, and to observe the course of a morbid process, to control and vary it, just as we observe the course of muscular contraction, or of the digestion of fatty matter; the extreme goal of our inquiry would be well within our reach. But we are still very far from possessing any such exact knowledge. We must content ourselves in the meantime with a few fragmentary portions of these ætiological series; and owing to the lacunæ which even these portions exhibit, we often find ourselves compelled to renounce the natural order altogether, and to admit the categories—inflammation, hypertrophy, morbid growth, &c., into our system. The anatomist is least of all to be blamed for adopting this course. Nevertheless, even he must never be forbidden to place his divisions upon the former and more general basis; and I have found that the structural changes of the lungs are peculiarly well suited for arrangement in ætiological series. It is only in this way that we can hope to master the great variety of inflammations, congestions, hæmorrhages, pigmentations, &c.; while, if we make use of these anatomical terms as our *fundamenta divisionis*, we find ourselves continually obliged to separate subjects which are naturally united, and to place others which have no connexion with each other, into the same group.

1. DISEASES OF THE LUNGS ASSOCIATED WITH INFLAMMATION AND CATARRH OF THE BRONCHI.

a. *Emphysema.*

§ 408. If we spread out the sputum of a patient labouring under catarrh of the larger bronchi (tracheo-bronchitis) upon a dark background, we very commonly notice globular masses of a white or greyish colour, about the size of a pin's head, which resolve themselves, when more closely examined, into a number of minute, spherical or hemispherical bodies, consisting of viscid mucus in which corpuscular elements are embedded. These globular masses are derived from large, and at the same time rather dilated, mucous glands; they are casts of single acini, such as their viscid secretion must necessarily produce, when this, as often happens under such circumstances, is retained for some time in its place of origin. They have been erroneously supposed to be secretions from, or casts of, the alveoli of the lungs; hence it has been inferred that the commonest and least severe bronchial catarrhs extend into the pulmonary parenchyma. This is quite a mistake. Even bronchi as large as a raven's quill are hardly ever involved in such catarrhs; and the parenchyma of the lungs suffers only from irregularities in the distribution of the inspired air, which, owing to the swollen condition of the mucous membrane, the presence of secretion in the tubes, and the violent respiratory movements (coughing, hawking) must inevitably ensue. Now this disorder, known as pulmonary emphysema, results only from such catarrhs as have lasted a long time; but of these it is so frequent and so uniform a consequence, that no doubt can be entertained concerning their intimate causal connexion, although the mechanism of this connexion has not been elucidated as precisely as might be desired. For our present purpose, a few hints on the subject must suffice.*

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* Cf. *Biermer* in *Virchow's* Handbuch der Speciellen Pathologie und Therapie, Bd. v., Abtheilung i., Lieferung 5.

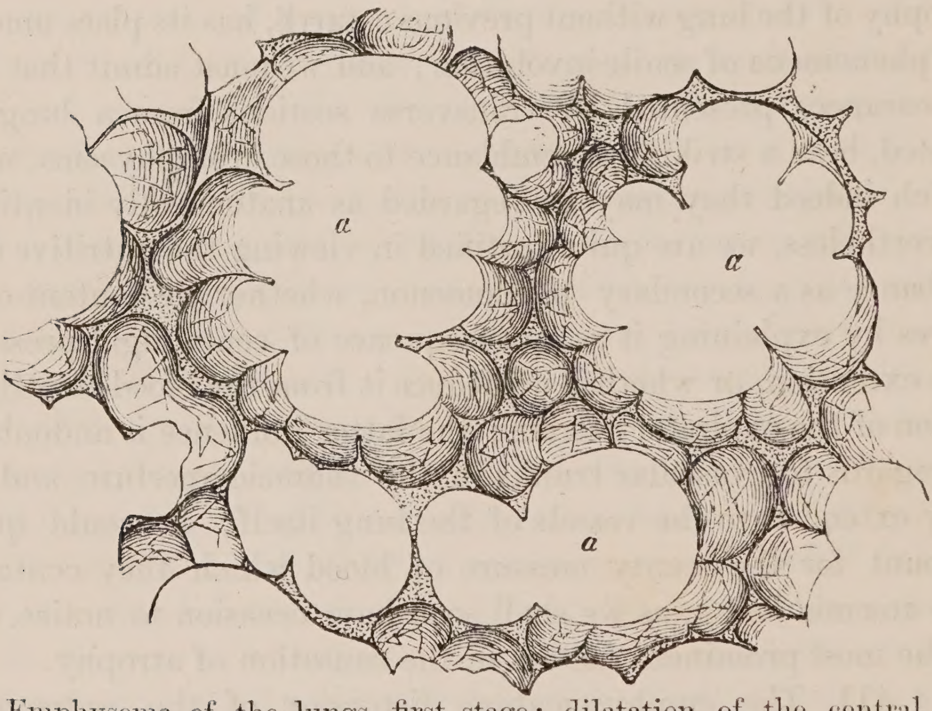
§ 409. The term Emphysema essentially denotes the distension, the inflation of the interstitial connective tissue of any organ with air, just as œdema denotes its distension with serous fluid. Now although true emphysema may affect the lungs like any other part of the body, the term is employed in an arbitrary way to denote a condition in which the pre-existing air-cavities, the infundibula and alveoli, are distended and dilated beyond their normal size. This dilatation, which is followed sooner or later by an atrophy of the dilated parenchyma, is clearly due to the operation of a centrifugal force, whether as pressure from within or as extension from without. That the pressure is a result of expiration, and the extension a result of inspiration, is obvious enough. The point at issue is this: to what extent can the presence of a catarrhal affection of the bronchi increase one or other of these factors so as to make it produce abnormal and excessive effects? Any one who carefully examines the mechanism of the respiratory process with a view to a solution of this problem will be convinced that an augmentation of either factor beyond its proper physiological limits can only be partial in extent, since, 1st, the inspiratory strain upon any given portion of lung-tissue can only exceed its normal limits when the due expansion of other parts of the same lung is interfered with, and the relatively healthy residue is consequently driven vicariously to occupy the empty space; and, 2nd, the expiratory strain can only cause dilatation, if there happen to be some yielding point in the thoracic walls, through which a sort of hernial bulging may be supposed to take place. This point is the upper aperture of the thorax, with its great vascular trunks which are subjected to incessant variations in calibre, and its other soft and displaceable contents. A uniform emphysematous dilatation, coextensive with the entire lung, cannot therefore be explained by any increase of expiratory pressure; and it can only be explained by increase of inspiratory strain, if we adopt the plausible hypothesis that during the antecedent bronchitis first one, then another bronchial tube is plugged with secretion, and so first one, then another segment of the lung subjected to an abnormal degree of distension. The disproportionate liability of the anterior edges of the lungs, which are nearest to the thoracic aperture and the great vessels, would seem to indicate that the augmented expiratory pressure, especially during the effort of coughing, had also some share in the production of emphysematous distension.

§ 410. We can readily understand, from the analogous effects of pressure and tension upon the tissues generally, how the abnormal strain to which the alveolar parenchyma is subjected, should lead to its consecutive atrophy. The second element of the structural alterations, *sc.* atrophy of the parenchyma, is thus brought into a very natural connexion with the same original cause as that to which the dilatation was ascribed. Caution, however, is imperative. We may ask ourselves whether the atrophy may not be primary, and the emphysema secondary, resulting from the atony of the wasted lung-tissue? This question cannot be met by an absolute negation. We know that an atrophy of the lung without previous catarrh, has its place among the phenomena of senile involution; and we must admit that the appearances presented by transverse sections from a lung so wasted, bear a striking resemblance to those in emphysema, with which indeed they may be regarded as anatomically identical. Nevertheless, we are quite justified in viewing the nutritive disturbance as a secondary phenomenon, whether we content ourselves by explaining it as a consequence of centrifugal pressure and extension, or whether we deduce it from the blood-expelling action of the expiratory strain; the latter influence is undoubted as regards the vascular trunks in the thoracic aperture, and we may extend it to the vessels of the lung itself; it would quite account for the scanty measure of blood which they contain; this anæmia being, as we shall soon have occasion to notice, one of the most prominent factors in the causation of atrophy.

§ 411. The emphysematous distension of the pulmonary parenchyma usually begins with a dilatation of that central infundibular cavity into which the lateral alveoli open (cf. fig. 126). This cavity, in its normal state, exceeds the diameter of the alveoli by about a third, so that in any transverse section made through a dried lung, we may, with a strong pocket-lens, or under a power magnifying at most fifty diameters, determine the number of the divided infundibula by the annular spaces distributed at equal intervals throughout the field. Each of these is separated from its neighbours by a double row of smaller rings; this is simply due to the fact that each infundibulum is provided with its own circlet of alveoli; hence in passing from the centre of one infundibulum to that of the next, we must traverse two such alveolar circlets. These divisions are especially marked in the first stage of emphysema, since those central cavities, which stand in the same relation towards the alveoli as the impluvium of a Pompeian house towards its chambers, are steadily increasing in width. Accordingly, when the emphysema is still comparatively moderate in degree (as represented in fig. 126), the large pores recurring at equal intervals, may be recognised even with the naked eye.

This, the first step in the process, occasions a demand for more space, which is mainly supplied by a permanent increase in volume of the emphysematous portions of the lung. Hence such lungs appear more bulky than normal lungs; the anterior edges on each side bulge forward towards the sternum and come into contact with each other, pushing the heart backwards and away from the thoracic wall. The sharp edge which each lung normally exhibits in this region gradually disappears, its place being taken by a rounded, bulging pad, which obliterates the boundary between the inner and the outer surface of the organ.

Fig. 126.



Emphysema of the lungs, first stage; dilatation of the central cavity of the infundibula, *a*, *a*, *a*. $\frac{1}{100}$.

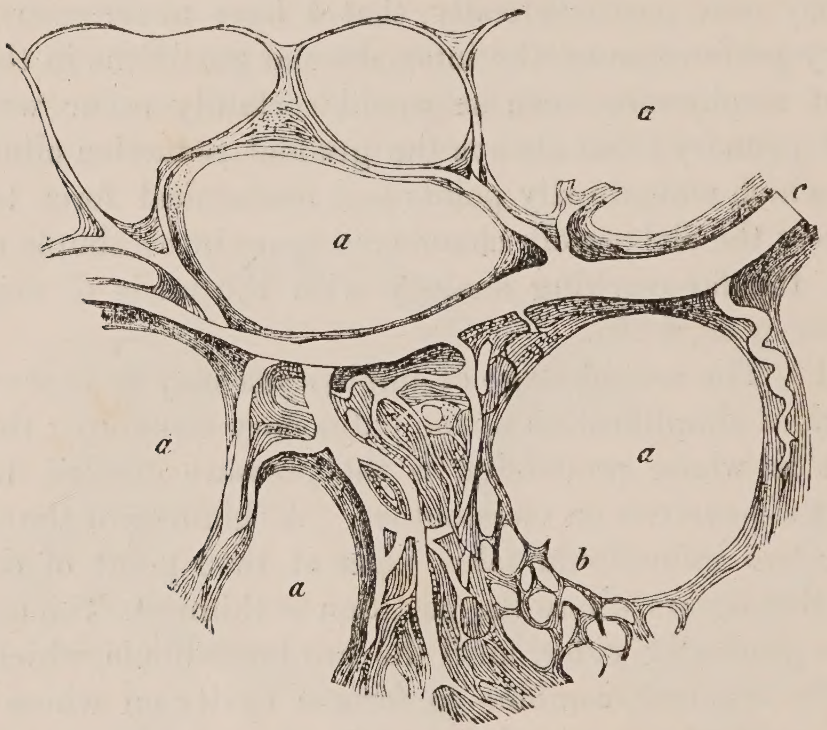
This visible increase in bulk must on no account be mistaken for hypertrophy. On the contrary, the dilatation of the central cavity of the infundibula is early associated with atrophy, which takes the form of a reduction in the height of the inter-alveolar septa. The infundibulum is gradually converted into a larger but still conical air-sac, whose inner surface is parcelled out by minute ridges—the only remains of the former septa. This condition is exactly comparable to the normal appearance of a frog's lung. In the human subject, it denotes a very advanced stage of atrophy, and the destruction of a great part of the respiratory surface.

I may state parenthetically, that I have never seen a preliminary perforation of the inter-alveolar partitions in this first stage of emphysema, such as would certainly occur were the atrophy primary; but always the gradual reduction alluded to above, which undoubtedly points to a mechanical force tending to convert the elaborately chambered space into a simple conical sac (cf. the far-reaching analogy with the mode of origin of retention-cysts, § 70).

§ 412. The second stage of emphysema may be described as a continued simplification of the pulmonary structure; the chief element in whose production is the pressure exerted by two adjacent air-cavities on one another. A thinning of the septum between two infundibula takes place at their point of contact. Perforation occurs where the partition is thinnest. The opening becomes gradually wider, until the two infundibula, which were originally separate, combine to form a cavity on whose inner surface a circular, projecting fold is the sole remnant of the wasted tissues; this surrounds the aperture of communication, which continues to increase in size (fig. 127, *a*). After this fashion, whole groups of infundibula become fused together; the resulting cavities all tend to assume a globular form, and there arise, particularly at the edges of the lungs, those simple thin-walled sacs, varying in size from a pea to a walnut, which we briefly term "emphysematous blebs."

In still higher degrees of emphysema, particularly in the senile variety, the atrophic condition of the parenchyma is also manifested by the fact that the lungs, after the thorax is opened, collapse far more completely than they usually do; if we lay hold of them with the intention of cutting them open, they shrink still more, the last residue of air being easily driven out. By pouring water on the cut surface, the parenchyma may again be distended; we then see the extent of the destruction which has taken place. The great space contained within the pulmonary pleura is traversed by only a few trabeculæ, corresponding to the main bronchi and vessels, together with some of the thicker interlobular septa. The finer elements of structure have entirely disappeared. Here and there we see ragged shreds hanging from the trabeculæ, bridging over some corners and filling others up. Everything is blackened by masses of accumulated pigment, since the portions of structure which survive are those which normally contain the largest amount of pigmentary matter, *sc.* the sheaths of the vessels and the bronchi.

FIG. 127.

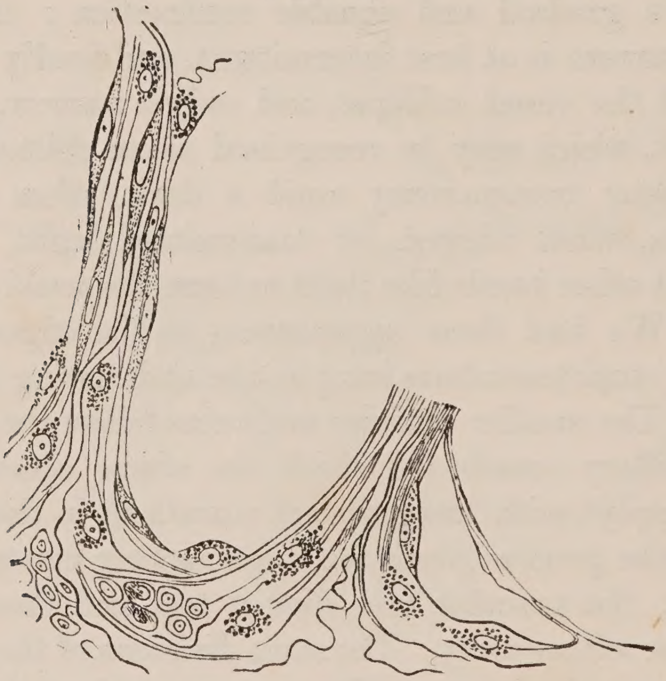


Emphysema of the lungs, later stage. The cavities *a*, *a*, have been produced by the complete atrophy of the inter-alveolar partitions of each infundibulum; partly too by the fusion of adjoining infundibula; *b*. Remains of obliterated septa, characterised by the number of unstriped muscular fibres which they contain (cf. fig. 128); *c*. Branches of the pulmonary artery. $\frac{1}{50}$.

§ 413. Having thus traced the emphysematous destruction of the lungs from its microscopic beginnings to its ultimate results, we turn our attention next to the peculiar structural alterations which accompany or cause the disappearance of the parts. The various tissues which make up the alveolar parenchyma are not all affected in the same degree. It is only the elastic tissue, and what still remains of the basis-substance of the connective tissue, which undergo a simple atrophy, a uniform shrinking and obliteration. The retrograde metamorphosis of the vessels is more complicated. First of all, the quantity of blood which passes through them in a given time undergoes an obvious diminution; and I have already allowed myself to suggest, that this deprivation of blood may perhaps be the connecting link between the mechanical cause of emphysema and the disturbance of textural nutrition. The calibre of the vessel undergoes a gradual and equable contraction ; the arrest of the blood-current is at first intermittent, and finally permanent; the walls of the vessel collapse, and only a narrow, ribbon-like band is left, which may be recognised as an obliterated vessel by its greater transparency amid a dark, often pigmented, parenchyma, when viewed by transmitted light, and by its uniting with other bands like itself to form the usual anastomotic network. We find these appearances in the edges of all such septa of an emphysematous lung as are undergoing atrophy and reduction. The smaller arteries and veins follow the same course as the capillary vessels (to which the above observations are meant to apply) with insignificant variations in the anatomical features of the process (their walls contracting instead of simply collapsing); the vascular tree dies at top, and then its larger branches also wither away. The main divisions of the pulmonary artery hold out the longest. The passage of blood through their capillaries being well-nigh arrested, some relatively wide anastomoses are opened up between the pulmonary artery on the one hand and the pulmonary and bronchial veins on the other ; so that (in some degree at least) the passage of blood from the right heart is provided for. In well-injected lungs these anastomoses appear as peculiar, elongated, unbranched, vascular arches, whose diameter is accordingly the same throughout, and which contrast very strikingly with a far more numerous assemblage of extremely tortuous and dilated arteries, for whose contents no such supplemental mode of escape has been provided, and which afford visible proof of the great increase of tension in the pulmonary artery (fig. 127, *c*). On a former page (§ 235) this increase in tension is suggested as a cause of the concomitant hypertrophy of the right ventricle.

§ 414. Observers have hitherto bestowed an almost exclusive attention upon alterations in the EPITHELIUM; because it was supposed that they would furnish an argument in favour of the doctrine that the atrophy of the lung-tissue was the primary phenomenon in emphysema. A very considerable aggregation of oil-globules is invariably found surrounding the remains of the nuclei of what once were epithelial cells; these elements being actually more apparent after they have undergone fatty degeneration, than in their normal state (fig. 128). These masses of granules are equidistant from one another, and may readily be demonstrated in all the stages of emphysema. Whether a portion of them may not belong to the connective tissue or to the obliterated vessels, is a question which we must leave open; for it is clear that all these elements must perish together, and we know that they are all as liable to fatty degeneration as are the epithelial cells. Again the nuclei, at least of the capillaries, are so superficial in position, that it would certainly be far from easy to bring incontrovertible evidence in favour of the exclusively epithelial origin of these granule-cells.

FIG. 128.



Specimen taken from the inner surface of a large emphysematous bleb.[1] Fatty residue of the lung-tissue, containing elastic fibres and fibres of unstriped muscle, coated with epithelial cells in a state of fatty degeneration. $\frac{1}{500}$. (Cf. 127, *b*.)

§ 415. The only tissue which does not unconditionally succumb to this universal atrophy is that of the unstriped muscular fibres. The presence of scattered bundles of these fibres in the alveolar walls of healthy lungs has recently been affirmed anew by *Colberg*. I cannot agree with my worthy *confrère* in his assertion that these bundles are absent in emphysematous lungs. On the contrary, it is in the trabeculæ of highly emphysematous and already thinned portions of lung, that I have most often found the thickest bundles of such fibres (fig. 128), and I believe that this discovery justifies me in asserting that these bundles are actually hypertrophied, since it would be very difficult to find any like them in healthy lung-tissue. Of course, this must not be taken to mean that *all* the muscular fasciculi become hypertrophied. On the contrary, it is very possible, though I have not observed it, that a retrograde metamorphosis and destruction of the unstriped muscular fibres is taking place elsewhere, while their hypertrophy and growth are restricted to certain tracts, which, perhaps for this very reason, maintain themselves in the residual parts of the parenchyma.

b. *Catarrhal Pneumonia.—Broncho-pneumonia.*

§ 416. On account of its lobular, or, if the word be preferred, its acinous structure, the lung has often been classed with the open glands; so too, because the alveolar walls are continuous with the mucous lining of the respiratory tract, the lung has been described as in some sort an immensely extended mucous membrane. Many admirable arguments may be urged for and against either of these views; a proof that the question belongs to that awkward group for which nature provides no answers. I should certainly have passed it by without notice, had not the pathological alterations of the lungs demanded that some answer, even though only a superficial one, should be returned to it. From the pathological point of view, we ought undoubtedly to insist upon the analogy of the alveolar walls to a mucous surface; for a comparison of the most important and frequent diseases of the pulmonary parenchyma with analogous conditions of the mucous tract, makes the former far more intelligible than they would otherwise be. I refer principally to inflammatory or pneumonic conditions of the lungs; for we distinguish—just as in mucous membranes—between a catarrhal and a croupous inflammation, regarding the alveolar walls in the light of a mucous surface, upon which, in the one case a corpuscular secretion is poured out (analogous to epithelial catarrh), in the other a fibrinous exudation. The analogy between the histological details leaves less to be desired than that between the clinical phenomena. For while catarrhal inflammation of a mucous membrane is far less important clinically than the croupous form, the reverse is the case in corresponding conditions of the pulmonary parenchyma. Croupous inflammation is our simple acute pneumonia, the prognosis in which is usually very favourable; while catarrhal pneumonia, both in its acute and chronic forms, is one of the most dangerous of diseases; among other ill effects, it lays the anatomical foundations of pulmonary phthisis.

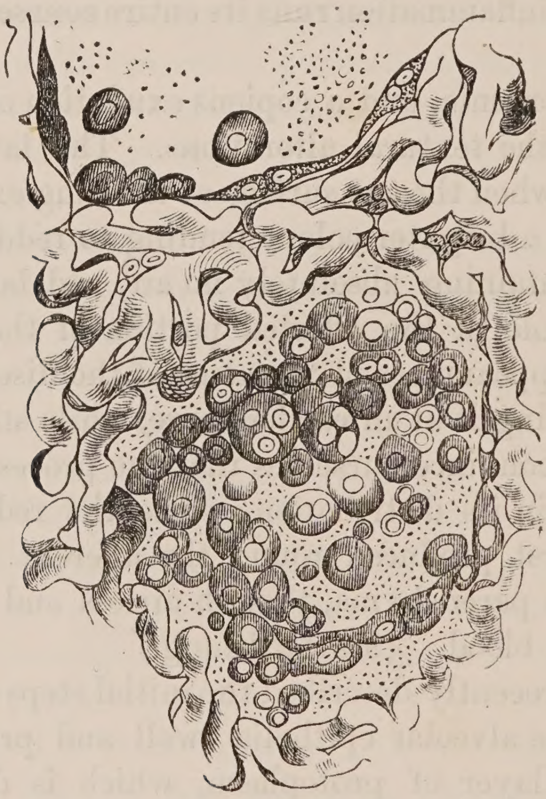
§ 417. THE ACUTE FORM. Confining our attention for the present to the acute form of catarrhal pneumonia, it is easy to show that youth is a powerful predisposing cause of this affection. In children under the age of five, hardly any other form of pulmonary inflammation occurs; the cause of this peculiar fact appears to me to reside in the greater irritability of the epithelial elements of the child's lung, inherited from the period of their developmental activity. The epithelial cells are far larger in size; they contain more protoplasm, and adhere less firmly to the alveolar surface than at a later period. Moreover the inflammation of the parenchyma proper is usually preceded by a catarrhal irritation of the bronchial mucous membrane, so that from this point of view the former may be regarded as an "abrupt transition" of the catarrhal process from the minute bronchi to the alveolar parenchyma—a transition for which the ground has long been ready. This may occur in various ways. So, the acute bronchitis which attends measles is characterised by its commonly spreading in the stage of desquamation from the nasal and tracheal mucous membrane to the minuter bronchi (capillary bronchitis), and then proceeding to set up inflammation of large segments of the lung—perhaps of half a lobe at once. Again, we have inflammation of the postero-inferior parts of the lungs, accompanying croupous laryngitis; this is essentially due to that unequal distribution of blood, air, and bronchial secretion, which is characteristic of this form of dyspnœa. For while the air accumulates mainly in the upper lobes, and along the anterior edges of both lungs, where it gives rise to acute forms of emphysema and bronchiectasy, the blood and secretions, under the influence of gravity and the pressure of the air, sink downwards and backwards, causing atelectasis, œdema, and ultimately catarrhal inflammation (cf. § 425 *et seqq*). Again, we have a series of cases in which a simple bronchitis extends *ab initio* into the finest ramifications of the bronchial tree; this occurs chiefly in badly nourished, scrofulous children, reduced by previous disease. Lastly, cases undoubtedly occur, and that not seldom, in which acute catarrhal inflammation runs its entire course independently of bronchitis.

§ 418. Hyperæmia, and a copious exudation of blood-serum, always precede the textural alterations. The latter are known to have begun, when the cut surface of the lung exhibits a firmer consistency and a brighter colour tending to reddish-white; the affected part containing absolutely no air, and being drier than usual. The whole of the affected portion of the lung usually presents these appearances at the acme of the disease; but if we succeed in catching it at an earlier stage, while still in progress, we may readily convince ourselves that the process, for a time at least, is insular in its distribution; since the reddish-white infiltrations are first produced round the afferent bronchi, while the intermediate parenchyma, though airless and œdematous, is still loaded with blood. (Marbled lung.)

Colberg has recently described the initial steps of the textural alterations. The alveolar epithelia swell and produce a thick and continuous layer of protoplasm, which is detached from the wall of the alveoli in transverse sections as a nucleated band. The individual cells then separate; their nuclei divide; an active corpuscular proliferation sets in; large spheroidal cells with vesicular nuclei are produced; these cannot be otherwise described than as epithelial elements; they proceed to fill the alveoli, spreading through the stagnant serum which these contain (fig. 129). The intensity of this corpuscular proliferation, the quantity of epithelial elements produced, determine the further course of the inflammation. A complete return to the normal state is undoubtedly possible. For obvious reasons, we cannot offer any reliable facts concerning the textural details of this process; we may assume, however, that the infiltration in such cases must be chiefly serous, and poor in cells, since we have ample evidence to show that the greater the number of those large, epithelioid masses of protoplasm, which are secreted by the alveoli in catarrhal pneumonia, the less likely is an inflammatory infiltration to end in resolution and absorption, and the greater the risk of its falling a prey to the second mode of retrograde metamorphosis, *sc.* caseation.

We can trace the infiltration through every stage in its passage from a fluid which is simply rich in corpuscular elements, to a mass consisting exclusively of cells, and finally to the cheesy deposit. Moreover these stages correspond to the transition of acute catarrhal inflammation to the chronic form (which very commonly occurs), and may indeed be regarded as the essential anatomical basis of the latter.

FIG. 129.



Catarrhal pneumonia. An alveolus and a half. The tortuous capillaries of the septa have been injected. The alveoli are filled with epithelial elements (derived from their walls) which are undergoing multiplication by division. $\frac{1}{300}$.

§ 419. THE CHRONIC FORM. It is very difficult for the morbid anatomist, without the aid of clinical data, to decide whether a catarrhal pneumonia, after the infiltration has become cheesy and so received the stamp of chronicity, was originally acute or chronic. The difficulty is partly owing to the fact that a cheesy mass may exist in the lung for a long period of time without undergoing any change; partly to the circumstance that the conditions which precede the actual inflammation, and which accordingly surround the cheesy deposit as stages in its development and extension, very often present exactly the same anatomical characters without possessing the same physiological significance. I refer principally to congestion and œdema, which also precede such inflammations as are chronic from the first; when, however, they are by no means indicative of irritation, but are rather to be viewed as the immediate consequences of the disturbance in the circulation of air and blood caused by the bronchitis. We must go thoroughly into this matter, since it is one of the most important and interesting links between the primary bronchitis and the consequent inflammation of the pulmonary substance in chronic catarrhal pneumonia. The "abrupt transition" of the inflammatory process from the bronchial mucous membrane to the parenchyma, as well as the immediate and primary development of parenchymatous alterations, do not possess anything like the same importance in the causation of chronic broncho-pneumonia, as in that of the acute variety; the "abrupt transition" being replaced by a more gradual process of extension. On the other hand, we have a long series of attendant and instrumental phenomena which stamp the process now with one, now with another external character, giving rise to the tolerably wide variations in the sum-total of morbid changes comprised under the common head of PULMONARY PHTHISIS. That our steps may be the surer on this difficult ground, we must distinguish rigidly between: 1st, The alterations in the bronchial tubes and their walls; 2nd, The changes in those portions of the parenchyma to which the affected bronchi lead.

§ 420. It is a tolerably well-known fact that many cases of phthisical destruction of the lungs start from a catarrhal affection of the respiratory mucous membrane, and particularly of those bronchi which ramify in the upper lobes. This catarrh is characterised partly by its singular obstinacy and tendency to recur, partly by the never-failing scrofulous enlargement of the retro-bronchial lymphatic glands (*Virchow*). The secretion is highly corpusculated, and therefore viscid and concentrated; hence, too, it adheres very tenaciously to the walls of the respiratory passages; this occasions disproportionately frequent, though in the main unsuccessful, efforts at coughing and hawking. Dissection shows the larger bronchi loaded with this secretion, while a certain number of the SMALLER TUBES appear to be completely plugged by it. On examining transverse sections of the latter, we find their walls permeated by a countless multitude of corpuscular elements, the boundary-line between connective tissue and epithelium obliterated, and the latter replaced by the above-mentioned thick layer of muco-purulent secretion. I have observed this condition in bronchi from 0·5 to 0·3 millimetres in diameter, and I connect it with the early disappearance of the basement-membrane, which is of such extreme thinness in these bronchioles that its very existence is a matter of some doubt. In the trachea and larger bronchi the basement-membrane acts as an important safeguard against the extension of catarrhal processes into the deeper tissues, just as the elastic networks, with which they are so abundantly provided, serve to resist the distension of the mucosa with inflammatory infiltrations. Both of these structural peculiarities gradually become less marked as we pass from the trunk of the respiratory tree to its branches; hence the narrower the bronchi, the more liable are they to become blocked by swelling of their lining membrane and by accumulated secretions, as a result of simple catarrh. Add to this that the persons most commonly affected are those whose respiratory organs are congenitally feeble (hereditary transmissibility of phthisis) or those whose vital powers generally, including their respiratory mechanism, have been weakened by febrile or other wasting diseases. The expiratory effort needed for the removal of the viscid and adherent secretion proves too great for the patient's powers; during the inspiratory act moreover, owing to the ease with which a compensatory dilatation of neighbouring portions of the lung may occur, no air forces its way past the viscid plug of mucus into the parenchyma behind it; the block becomes chronic and ultimately permanent.

The ulterior consequences of the more or less complete occlusion of the bronchi which has been thus produced, may be traced in various directions (§ 425); for the present we will confine our attention to the primary disorder.

§ 421. Supposing the secretion of muco-purulent matter to have entirely ceased, the stagnant fluid becomes inspissated, its corpuscular elements die, and a yellowish-white, greasy plug is left, which protrudes from the cut surface when the lung is squeezed, and which thus serves as a guide to the original position of the tube. At a later period, cholesterin and earthy salts may be deposited in the interior of the plug; this change however, is almost invariably associated with the calcareous impregnation of large pneumonic foci, which form, as we shall immediately see, round the obstructed tubes.*

The bronchial wall itself cannot, under such circumstances, maintain a passive attitude. The retained secretions become decomposed; and the products of decomposition act as a persistent irritant, whose intensity varies in proportion to their quality. At the same time, those phenomena of proliferation in the bronchial walls, which were briefly alluded to above, increase both in extent and intensity; a series of very characteristic structural alterations being developed, which fall under the common head of "reaction against a superficial irritant."

§ 422. A. First among these comes an inflammatory overgrowth of all the structural elements of the bronchial wall, and especially a progressive fibroid thickening of the peribronchial connective tissue, the PERIBRONCHITIS CHRONICA of *Virchow*. Although it is usually difficult to follow up the bronchi to their finer ramifications with the scalpel, we now find them getting relatively thicker as we approach their terminal divisions. When cut across (and the bronchi are more often divided transversely than longitudinally when the lung is incised) the thickened tubes present a striking resemblance to solid nodules; for their lumina are nearly obliterated, partly by the thickening of their walls, partly by viscid secretions; hence they used formerly to be taken for tubercles. The error was quite excusable, for it is certain that conditions of this sort are intimately associated with tuberculosis; moreover, if the knife should by chance have been carried through the terminal tuft of bronchioles into which a single tube breaks up, and the individual twigs, all equally diseased, and all divided at right angles to their axis, present themselves to the naked eye on the cut surface of the lung, they look exactly like a "nest of miliary tubercles." Peribronchitis is commonly associated with a fibroid overgrowth of the interlobular connective tissue; this flows very naturally from the direct continuity of the peribronchial with the interlobular connective tissue, at the roots of the pulmonary lobules.

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* It has been asserted that what are known as "pulmonic concretions" (*Calculi pulmonales*) consist solely of the bronchial secretions which have become inspissated and calcareous. I do not wish to deny the existence of these bronchial calculi. But I nevertheless believe that very many pulmonic concretions, especially those which are coughed up periodically in considerable numbers (whence the term Phthisis calculosa), represent entire pulmonary lobules which become impregnated with earthy salts, and then, like foreign bodies, are set free from their connexions by suppuration in the interstitial connective tissue. (*See* below.)

§ 423. B. Again, the secretions may accumulate in such quantities as to distend the bronchial tube for a short distance and to thin its walls; this sets up a condition closely analogous to the formation of retention-cysts in other organs. We must bear in mind, however, that the etiology of the process may be, and in most cases probably is, far more complicated. The partial blocking of certain bronchi by plugs of secretion is necessarily followed by an increased rush of air to those parts of the lung which are still pervious, causing them to be permanently dilated. The reader will recollect that it is just the compensatory variety of emphysema which best admits of a mechanical explanation. Now compensatory emphysema is relatively rare in phthisical lungs; in its place, however, we very commonly find a CYLINDRICAL DILATATION OF ALL THE MINUTER BRONCHI, of those more especially which dip immediately into the alveolar parenchyma. On cutting open a bronchus from the root of the lung, we find that the scissor-blade advances with greater ease and certainty as we approach the periphery of the lung; indeed, we are often able to follow up branches no bigger than a raven's quill close under the very pleura. This form of bronchiectasy contrasts markedly with the ordinary catarrhal variety, inasmuch as the bronchial wall is extremely thin, instead of exhibiting a hyperplastic thickening of all its textural components. This thinning may go so far as to obliterate all the specific characters of the bronchial wall, converting it into a thin, glistening membrane, which lines a cavity of considerable size. To attain this result, the elastic networks are dragged asunder; the muscular coat separates into fasciculi of varying width, which recede from one another, leaving fissure-like intervals between them; the mucosa proper, so far as my observation goes, retains its normal thickness, so that the thinning appears to be confined to the outer layers of the bronchial wall. Very striking is the lack of vessels in these dilated bronchi. The capillary meshes are very wide, the arteries and veins are stretched and their calibre narrowed. The mucous surface is always in a state of catarrh; indeed, a general catarrh of the bronchi underlies the whole group of disturbances which we are now considering, and I venture to suggest that the diminished cohesion of the textural elements of the inflamed bronchus may even contribute not a little to its dilatation. The catarrhal secretion is extraordinarily rich in corpuscular elements, and contains but little water; it sticks to the bronchial wall, and displays a tendency to accumulate in considerable quantities. Bearing this fact in mind, we may very naturally interpret the appearances described above, *sc.* of dilated bronchi, crammed with secretion—by supposing the dilatation to have been primary, the accumulation of secreted matters secondary. This gives us a firm basis on which to ground our theory of the morbid process as a whole; inasmuch as its extension from the portion of lung originally affected to neighbouring parts, may be in some degree facilitated by the antecedent compensatory dilatation of the terminal bronchi. As regards the further course of the disease, particularly in reference to the alterations in the pulmonary parenchyma, it is a matter of indifference whether the obstructed bronchus was or was not previously dilated.

§ 424. c. The inflammation of the mucous lining of the bronchi may, at any period in its course, diverge in a third direction; it may pass into ULCERATION. By this term we must not understand that simple form of "excoriation" usually known as a "catarrhal ulcer" when it occurs on the mucous lining of the mouth or on the skin, but a truly destructive process, which eats away layer after layer of the mucous membrane (previously infiltrated with corpuscular elements) and mingles them with the secretion. As regards the intimate nature of this ulcerative process, it need only be remarked that in some instances it certainly deserves to be called "tuberculous." I have in my possession a phthisical lung, in which the dilated bronchi of the second and third order exhibit tuberculous ulceration in its most typical form (§ 384). Moreover *Virchow* has repeatedly directed attention to the presence of scattered miliary nodules on those bronchi which lead to fully-developed vomicæ. Hence we may infer that tuberculosis sometimes takes a very decided part in the production of these bronchial ulcerations; more than this we are not justified in assuming. As a rule, there are no miliary nodules to be found. The destructive process must then be regarded as a simple ulceration. Under the influence of the stagnant secretions, whether that influence be chemical or mechanical in its mode of action, the most superficial layer of the infiltrated mucous membrane undergoes necrobiosis in patches. This is followed by a more or less lively reaction in the deeper layers, resulting in the detachment of the necrosed tissue. We thus get a sharply-circumscribed, shallow defect, often a mere roughness, coated with a yellowish-white, friable fur, which cannot be washed off, but may be removed by scraping. By a repetition of this morbid process, the infiltrated wall of the bronchus is speedily eaten through; the ulceration extends to the pulmonary tissue, which no longer contains any air, and has been converted into a substance most excellently adapted for the spread of the destructive changes. To this point however, we shall return hereafter.

§ 425. Passing now to the ALTERATIONS IN THE PARENCHYMA, we must consider in the first place, a series of characteristic effects, produced by plugging of a bronchus, in that portion of lung-tissue which lies behind the point of obstruction. This series of effects can be artificially produced. The experimental section of both vagi, which interferes with the proper closure of the glottis, allows morsels of food to slip from the pharynx into the respiratory passages; this causes plugging of a large number of bronchial tubes, and affords most instructive examples of the early stages of the process. First among its effects is ATELECTASIS, *i.e.* collapse of the alveoli. A sharply-circumscribed conoidal piece of lung-tissue, exactly proportionate in size to the calibre of the obstructed bronchus, receives less and less air at each inspiration; finally, the access of air is altogether checked, and the inspiratory force which was previously spent in inflating this portion of the lung, transfers its operation to the neighbouring parenchyma (compensatory bronchiectasy—*see* foregoing paragraphs), and the part in question is left entirely to itself. The elastic reaction of the parenchyma comes into play, endeavouring, by the complete expulsion of the residual air, to reduce the part to its natural size. Should this attempt be successful, the acquired collapse becomes quite undistinguishable from the congenital variety—the condition of the lung into which air has never been admitted. The collapsed part is smaller than it was; if its base (as generally happens) is turned towards the periphery, we notice a depression of corresponding size on the pleural surface, with the little protuberances (each = a lobule) which are so characteristic a feature of the fœtal lung.* The surface is accordingly uneven and tuberculated. In colour and amount of contained blood, the affected part, at least in the earlier stages, also reminds us of fœtal atelectasis. The wedge of lung-substance is of a reddish-purple hue; it shines through its pleural covering with a bluish lustre. But it is in the amount of contained blood that a profound difference, and one which makes itself felt in the further evolution of the morbid state, is speedily established; for in the acquired form of atelectasis the HYPERÆMIA, which was at first only simulated by the approximation of the capillaries to one another, speedily becomes real.

§ 426. In the fœtal lung, no disproportion can exist between the length and width of the capillaries on the one hand, and the space which they occupy on the other. It would be impossible for the vessels to extend or develope further within the fixed limits of the space assigned to them. It is otherwise in the case of acquired atelectasis. The non-expansion of the lung is now an abnormal condition, for the occurrence of which no thought was taken, no provision made—to speak metaphorically—during the extra-uterine transformation of the lungs into breathing organs. This transformation involves the most luxuriant possible evolution of the vascular apparatus. If therefore, at a time when this evolution has become an irrevocable fact, a complete contraction of the elastic part of the parenchyma should occur, this must necessarily give rise to a disproportionate impairment of the length and calibre of the vessels. The framework of elastic fibres at once becomes a mechanical obstacle, interposed between that portion of the blood-channel which projects freely into the infundibulum and the alveoli—*sc.* the capillaries—and the interstitial or interlobular afferent and efferent vessels. The blood-current is retarded; the blood accumulates in the capillaries, and the collapsed portion of lung becomes congested.

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* The pulmonary lobules must not be confounded with the infundibula; each of the former contains nearly twenty of the latter.

The congestion is followed sooner or later by an exudation of serum into the alveoli—the collapsed part becomes ŒDEMATOUS. Its bulk increases in proportion to the degree of œdema; it rises to its former level on the pleural surface; nay, it may even project beyond it as a flat, elastic swelling. Its consistency is doughy; it retains the imprint of the finger; its free surface is of a bluish tint; on section it appears of a dark reddish-brown colour, moist and smooth;—in short, it resembles the spleen so closely in its external aspect that the term SPLENISATION is the best that can be found to denote its condition. Now it is quite plain that the splenisation of lung-tissue does not necessitate any antecedent atelectasis for its production, but only a sufficiently intense degree of congestion with effusion of serum into the alveoli. Every passive hyperæmia, and especially that hypostatic congestion of the lower lobes which accompanies the gradual failure of the heart's contractions in most modes of dying—in heart-disease, in typhoid fever, and other states of exhaustion—may lead to splenisation through an œdema which expels the contained air. At this point, therefore, the process which we are now considering loses all its anatomical individuality; it would be impossible to tell, by examining the affected portion of lung-tissue, whether it had been previously atelectatic or not, but for the clue afforded by the wedge-shaped limitation of the atelectasis, as also by the fact that the hypostatic variety of splenisation is only found in the dependent parts of the lungs. Under ordinary circumstances however, it would certainly be impossible to recognise a wedge of lung which had undergone splenisation after atelectasis, in the midst of a lower lobe affected with hypostatic splenisation.

§ 427. Splenisation, in the most general sense of the word, appears to offer an exceptionally favourable soil for the development of inflammatory changes. It may even replace the initial congestion of acute inflammation, and so lead to lobular and lobar infiltrations, which, however, are invariably of a catarrhal character. This is the order of events in the hypostatic pneumonia of patients in a typhoid state, or suffering from extreme exhaustion, as well as in those broncho-pneumonic complications, occurring in the course of phthisis, which we are about to consider.

Apart from inflammation, diffuse splenisation of the lower lobes may be followed either by recovery or by death; atelectatic or lobular splenisation, by a series of further changes which are successively evolved by the continued operation of those forces whose action has already begun. We will notice two of the members of this series more particularly, viz. "chronic œdema," and "slaty induration."

§ 428. CHRONIC ŒDEMA is primarily distinguished from splenisation by the absence of congestion. It would seem as though the supply of blood to the affected part were more and more impeded by the growing amount of the serous effusion; this is strictly analogous to what invariably accompanies all pneumonic infiltrations (§ 431); the infiltrated material cannot yield, because it is enclosed in a cavity which is not susceptible of unlimited distension; hence it expels the blood, which *can* yield, *i.e.* can enter other channels besides those which traverse the infiltrated part. The latter swells to a still greater size than before, if possible, becoming at the same time paler in hue, and finally exhibiting only a few red striæ, winding over a surface which is otherwise of a uniform pale yellow colour. On cutting into it, there flows from the cut surface a clear, highly-concentrated serum, free from air-bubbles, in which yellowish-white, dust-like particles may here and there be detected. The cut surface itself also appears to be sprinkled with a similar yellow dust, which turns out, on microscopical examination, to consist of cells undergoing fatty degeneration, the so-called "granule-cells." The paleness and brawny look of these foci contrast strikingly with the lively red hue of the surrounding tissues, whose colour is deepened by the collateral fluxion, *i.e.* by the accumulation of the blood which is unable to penetrate into the affected part itself.

§ 429. SLATY INDURATION of the lung, at least as regards the parenchyma, must also be viewed as a termination of prolonged atelectasis, and not as a chronic inflammation. It is indeed by no means easy to maintain a sharp boundary-line in this matter. Grey induration is normally found in association with the chronic peribronchitis described in § 422, which in its turn is as constantly bound up with an inflammatory overgrowth of the interstitial, *i.e.* interlobular connective tissue. The latter pushes its way from every side between the islets of parenchyma, in the form of progressively widening trabeculæ; it separates them from one another and compresses them, assuming an unnatural prominence in the sum-total of anatomical appearances. It is important nevertheless to bear in mind, that the alveolar parenchyma itself takes no active share in the inflammatory change. What little bits of lung-tissue we notice, contain neither air nor blood; nevertheless the septa between the individual alveoli may still be demonstrated, and it is not till a very late stage of the process that the approximated surfaces really become fused together, and the interstices between them obliterated. If we try to inject the part, our injection penetrates only into the vessels of the interlobular connective tissue, while the former parenchyma does not admit it. The most characteristic feature of grey induration is the presence of black lung-pigment in enormous quantity. It occupies the interstitial connective tissue as well as the atelectatic parenchyma. It consists of small black granules, aggregated together in the interior of cells, but which are also scattered free throughout the tissue. In isolated patches, as large as a lentil, usually round or elongated in shape, the deposit of pigmentary matter is peculiarly dense, giving them a deep black hue. These patches indicate the site of former hæmorrhages; they are obsolete hæmorrhagic foci. The pigment, in slaty induration, is undoubtedly derived from the colouring-matter of the blood. For the circumstance that the pigmentation is most intense in those very portions of the lung which are earliest shut off from the inspired air, makes the hypothesis that this pigmentary matter is inhaled, untenable; moreover, side by side with the black pigment in these lungs, we find a number of intermediate granules of a brown or red hue, which are more nearly related to the colouring-matter of the blood, and represent the earlier stages of pigmentary metamorphosis.

It is also to be noted, that the aspect of a piece of lung affected with peribronchitis, overgrowth of interstitial connective tissue, and slaty induration, is so exceedingly characteristic, that it has long served as the type of "healed tuberculosis." "We find on the pleural surface, layers of exudation of an almost cartilaginous hardness, which send radiating bands of a white colour into the interstices between the lobules ; amid these we find a number of transversely-divided bronchi filled with cheesy or even calcareous plugs, and whose walls have undergone fibroid thickening ; the space between the bronchi and the interlobular septa being occupied by a slate-grey, dry, airless and very tough parenchyma."

§ 430. Inflammation and Caseation. We have hitherto broken off all the threads of our inquiry at the point where inflammation of the lung-tissue sets in. We have found that the tissue in which the inflammation begins is no longer, as a rule, the normal parenchyma of the lungs, but a texture in various stages of hyperæmia, atelectasis, splenisation or œdema. We have found that the inflammatory changes in the bronchial tubes reach an advanced stage before they extend to the surrounding parenchyma. On the ground of the causal connexion between the bronchial and the pulmonary inflammation, *Virchow* has given the name of broncho-pneumonia to the process in question ; to him we also owe the term "cheesy" or "dry" pneumonia, which has reference to the quality of the infiltration. From the histological point of view, the term "catarrhal inflammation" is the best ; to this we prefix the clinical epithet "chronic," on account of the slowness of its course.

The infundibula and alveoli in the neighbourhood of the diseased bronchi, become filled with corpuscular elements which separate from their walls ; these are epithelioid, large, spherical, or if angular, their angles are rounded off ; they are furnished with round, comparatively small and lustrous nuclei. The textural details are therefore identical with those described in the acute form of catarrhal inflammation (§ 418). Indeed, we must add that it is quite impossible to decide (from the anatomical appearances alone), whether a recent infiltration, *i.e.* one which has not yet become cheesy, was acute or chronic *ab initio ;* even when the clinical symptoms bear witness to the chronicity of the disease as a whole, even when we find the various stages of the inflammation side by side in the same lung, we cannot positively reject the suspicion that the actual infiltration, like that formerly described, may have occurred within a very short time. Correlated with this is the possibility discussed in § 418, that every acute catarrhal pneumonia, however sudden and well-marked its onset, may pass into the chronic form, give rise to cheesy deposits, and so lead to pulmonary phthisis.

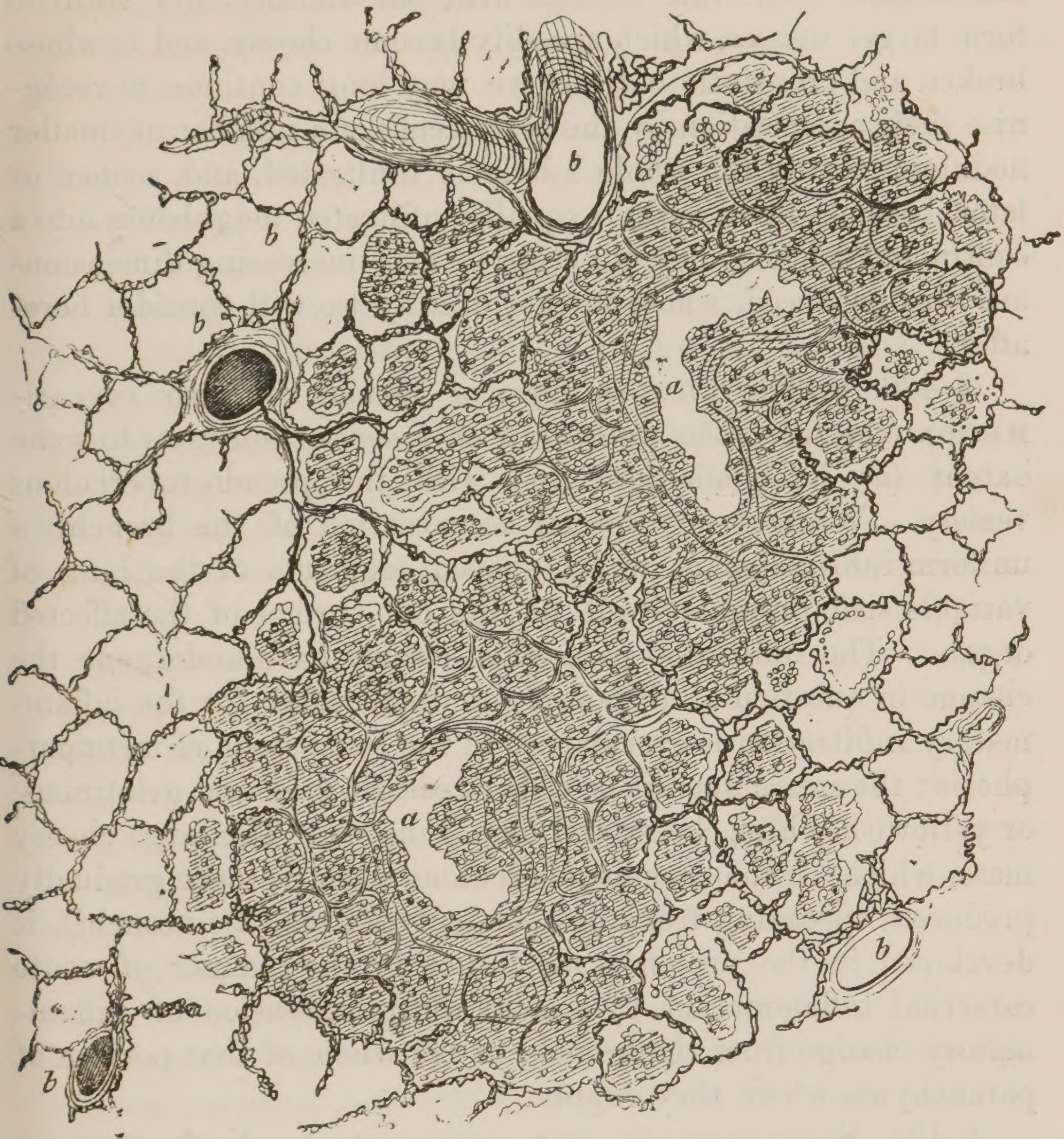
§ 431. All this tends to show that we must give up all hope of finding in the ascending series of morbid changes, any criterion which will enable us to distinguish between chronic and acute inflammation; in the descending series, however, we *do* find such a criterion, viz. the CASEATION of the inflammatory products. The occurrence of caseation—a fatty degeneration of corpuscular elements, modified by the abstraction of water—implies the co-existence of various favourable conditions. Of these the following are the most important: excessive accumulation of cells in close contact with one another, owing to the absence of any intercellular fluid; a gradual arrest of the circulation, which serves as the proximate cause of the actual impairment of nutrition. Now in catarrhal inflammation we have a *desquamation of epithelial elements* going on for a certain length of time, and associated with a difficulty or even an *impossibility of their removal* owing to plugging of the bronchi; these causes are amply sufficient to account for the most excessive accumulation of corpuscular elements in the alveolar parenchyma, for the expulsion both of intercellular fluid and of blood, and consequently for the cheesy variety of necrobiosis. The cells in the alveoli become cloudy, owing to the presence of fat granules in their interior; this change betrays itself to the naked eye by a sharply-circumscribed, yellowish-white opacity in the centre of the deposit; and no point can be more accurately determined without the aid of the microscope than the actual progress of this very change. Within its area, the pulmonary texture undergoes complete obliteration; only the residual pigment interrupts the homogeneous uniformity of the cheesy mass here and there with a dark-grey marbling. This by no means implies the actual destruction, the disappearance of all the structural elements of the lung-tissue; so far as the needs of the organism are concerned indeed, they have already perished; but the stoutest among them, the elastic fibres and the coats of the larger arteries, maintain their individuality for a long time, and reappear during the softening which usually ensues.

§ 432. The completion of cheesy metamorphosis establishes a state which tends but little of itself to further changes; it serves accordingly as a pledge of the relative chronicity of the entire process. This justifies us in adopting caseation as the anatomical criterion of chronicity, as regards the inflammation. To avoid any sudden break of continuity between the present doctrines and those formerly held, which have so thoroughly impregnated the professional mind, that without an adequate knowledge of them we are hardly able to come to any understanding with our senior *confrères*, I ought to state, that the cheesy matter alluded to above, is identical with what used to be known as "crude tubercle," and regarded as the sole starting-point of phthisis. At the present day, we must reserve the term "phthisis tuberculosa" for those very numerous cases, in which the presence of MILIARY TUBERCLES in the connective tissue and on the vessels of the diseased lung can be actually demonstrated; we must admit however, that our forerunners had a very clear perception of a fundamental truth, when they asserted that pulmonary phthisis, at a certain stage in its progress, extended its ravages by means of a yellowish-white, friable material. Nay, we may even go beyond this; we may retain *Laennec's* distinction between "tubercular infiltration" and "tubercular granulations," in so far as these terms correspond with the two chief naked-eye appearances of catarrhal broncho-pneumonia.

§ 433. A. PSEUDO-TUBERCULOUS BRONCHO-PNEUMONIA corresponds to the "tubercular granulations" of *Laennec.* It denotes the very ordinary case, in which the inflammatory infiltration of the alveolar parenchyma is primarily limited, and very rigidly limited, to the circumference of the smaller and smallest bronchi. The cut surface of the lung exhibits a number of grey, translucent nodules, with a whitish centre, varying in size from a poppy-seed to a grain of millet, and which therefore are really as like miliary tubercles as anything can be; they feel hard, are seldom solitary, but are usually aggregated together in clusters of from 5 to 10; these clusters being principally situated in the middle of the lobules, while their periphery continues free. The parenchyma in which they are embedded sometimes appears to be quite normal; it is never really normal, but is always either congested or collapsed, spleen-like or simply œdematous, more rarely emphysematous and pale. Whatever may be the condition of the parenchyma in other respects, the frequent occurrence of a zone immediately surrounding the nodules, and containing a reddish-grey, clear or slightly turbid, synovia-like, glutinous infiltration (*infiltration gélatineuse* of *Laennec*) is highly characteristic. The presence of this zone indicates an atony and puffiness of the tissues, which immediately precedes their infiltration with corpuscular elements; it is sometimes barely noticeable; in other cases it extends so far as to form a common areola for all the nodules of a single group; sometimes it may spread through an entire lobule, or even through large wedge-shaped segments of the lung. In the latter case, it is very difficult, if not impossible, to distinguish between gelatinous infiltration and the chronic œdema of an atelectatic part; I mean that the two conditions have repeatedly been confounded with each other.

§ 434. Histological analysis of the "grey granulations" yields the results depicted in fig. 130. The drawing shows two broncho-pneumonic foci (false tubercles), as large as millet-seeds, under a low magnifying power. At *a a*, in the centre of each granulation, are two bronchioles transversely or obliquely divided; they are plugged with a cheesy mass, which, however, owing to its great friability, has partially dropped out while the section was being made; the elastic layers of the bronchial wall are dissociated, and, together with the adjoining alveoli, infiltrated with a substance which once consisted of cells, but which has now become cheesy. The zone of caseation embraces two or three rows of alveoli; this is evident from the residual elastic elements of the alveolar framework. Next comes a zone in which the infiltration is actually taking place; at this point, higher magnifying powers would enable us to see appearances like those in fig. 129; still farther outwards, we see lung-tissue which is, as yet, comparatively normal. A successful injection of the pulmonary artery shows us how far the vessels still admitted blood into the affected area during life. We see that they are nowhere pervious quite up to the cheesy part of the deposit, while in the area of recent inflammation they are all filled with injection. I repeat, that only one inference can be drawn from these appearances, *sc.* that an infiltration, excessive in amount and rapidity of increase, has compressed the blood-vessels, causing its own necrobiosis and conversion into cheesy matter.

FIG. 130.



Two minute broncho-pneumonic foci. (*Laennec's* "tubercular granulations.") *a a.* The lumina of two adjacent bronchioles, whose cheesy contents have in part dropped out; their walls are infiltrated with cells, and pass uninterruptedly into the catarrhal infiltration of the surrounding parenchyma. The number of the infiltrated alveoli may be recognised by the arrangement of the elastic fibres; *b b b.* Blood-vessels. $\frac{1}{100}$ mm.

§ 435. The further progress of the alterations may be very satisfactorily traced even with the unaided eye, on the cut surface of the affected organ. The grey nodules gradually increase in size; the central opacity in each becomes a distinct cheesy spot; the nodules come into contact with one another, and unite to form larger masses, which speedily become cheesy, and in whose broken and crescentic outlines we may long continue to recognise their composition by the coalescence of a number of smaller nodules; finally the whole lobule is infiltrated, and, sooner or later, becomes fused with its equally infiltrated neighbours into a continuous whole; cheesy masses of ever-increasing dimensions are thus produced, whose further destiny we will consider hereafter.

§ 436. B. The DIFFUSE form of lobular or lobar INFLAMMATION (the *tubercular infiltration* of *Laennec*) contrasts to some extent (at least anatomically), with the pseudo-tuberculous variety. Without any special accentuation of the bronchi, a uniform infiltration of wedge-shaped segments of the lung of variable size, presents itself on the cut surface of the affected organ. The infiltrated parts must clearly have undergone the change in question at all points simultaneously; for the inflammatory infiltration is everywhere in the same stage of metamorphosis; the entire deposit is either reddish-grey and gelatinous, or yellowish-white, cheesy and homogeneous. The large cheesy mass, which, in the pseudo-tuberculous form, is more gradually produced, spreading from independent centres (the bronchi), is developed in the present case rather in the manner of acute catarrhal inflammation, by a more abrupt extension of inflammatory change from the bronchi to the whole of that portion of parenchyma which they supply.

§ 437. SOFTENING OF THE CHEESY MASS.—FORMATION OF VOMICÆ. The length of time during which the cheesy mass remains unaltered in the lung, depends partly upon its size, partly too upon circumstances which have hitherto eluded detection. We may fairly say, that the greater the size of a cheesy mass, and—in all probability—the more rapidly it has reached this size, the more imminent is the risk of softening at its centre, with the consequent formation of a cavity. The ordinary cheesy mass, which results from the coalescence of a large number of smaller nodules, usually reaches the size of a hazel-nut, before any sign of softening makes its appearance; on the other hand, cheesy infiltrations of single lobules, or of groups of adjacent and coalescent lobules, which have been rapidly developed, commonly undergo a correspondingly rapid softening; so that in these cases we find cheesy deposits of various dimensions side by side, all equally far advanced in softening.

§ 438. The process of softening itself, consists in a mere addition of fluid to the solids already present, without any development of fresh structural elements. The dead and shrunken cells, and the molecular *débris* amid which they lie, are loosened and suspended in a moderate amount of fluid, which makes its appearance in the centre of the mass. It is hard to see the necessity of this very constant phenomenon. I assume that some part of the solid albuminous matters is converted into soluble modifications, by prolonged digestion at a temperature of 37·5° C., and that the latter attract as much water from their environment as is necessary for their solution.

§ 439. I have already remarked that the liquefaction of the cheesy matter, its conversion into a flocculent, pus-like pulp, invariably begins in the centre of the deposit. This naturally leads us to inquire what share the bronchioles, which occupy the same position, may have in the production of the vomicæ. They are themselves preformed cavities. But, as we have already seen, they are usually stopped up with old secretions. It is only if the latter are the first to soften, that we can describe the excavation as "starting from the bronchi." This seems actually to be the case in the majority of instances. If we put aside the galloping form of multiple lobular infiltration to which allusion has already been made, in which softening occurs over large areas without any communication between the bronchi and the softened parts (Phthisis acuta), we may take it as a nearly invariable rule, that ULCERATION OF THE BRONCHIAL WALLS (fully described in § 424) prepares the way for actual excavation; whether it widen the bronchial tube at the expense of its walls even before the caseation of the surrounding parenchyma, and before the general rigidity which this occasions; or whether it be that the caseation, upon the whole, is merely a "zone of infiltrated tissue" round the wall of the bronchus—the disintegration of the pulmonary parenchyma being thus immediately consequent upon the complete destruction of the bronchial wall. The latter is undoubtedly the case when the bronchi are already dilated; so that, on cutting them open, we come upon perforations in the mucous membrane, through which a probe may be passed into the softened centre of a small cheesy nodule. Should the cavity have already attained a certain size, the afferent bronchus usually opens into it by a short, as if abruptly truncated stump, and does not allow of any certain inference concerning its share in the formation of the vomica.

§ 440. The chief element in this series of changes, next to the softening itself, is undoubtedly the establishment of a free communication between the larger air-passages and the vomica; and here I must assert, in opposition to statements of a contrary nature, that it is always the trunk of the afferent bronchus, very rarely that of one which courses past the cheesy deposit, which is laid open. The semblance of a lateral aperture may be readily produced by the circumstance that the cavity, after the total destruction of the afferent bronchus, has reached the point at which the latter was given off at an angle from a larger tube; so that the mouth of the secondary bronchus appears henceforward as a hole in the wall of the main bronchus, and as the direct and immediate mode of access to the interior of the cavity.

After the first evacuation of the accumulated products of softening, putrefactive changes usually associate themselves with the phenomenon; these changes, however, are always restricted to the most superficial layer of the cheesy matter, and are accordingly of little moment for the life of the patient. Small yellowish fragments continue to separate from the inner surface of the cavity, fragments which resemble morsels of food, bread-crumbs, &c. On examining them more carefully, we find a considerable quantity of elastic parenchyma, mixed up with shrunken cells and greasy, stinking, putrid *débris*. Their appearance in the sputa is a sure sign that the cavity from which they come is still increasing in size.

§ 441. Let us now contrast with this picture of decay and destruction, those changes which are instrumental in checking the progress of disintegration. These invariably set out from the interlobular connective tissue and the pleura, and exhibit the general character of "reactive inflammation at the periphery of the lobules," excited by the extensive disorganisation in their interior; individually, however, they exhibit manifold variations, to which the NAKED-EYE APPEARANCES OF THE PHTHISICAL LUNG in the later stages of the disease are really due.

Each particle of the pulmonary parenchyma which has undergone caseation is a *caput mortuum;* its connexion with the organism must, sooner or later, be broken in one way or another, and the continuity of the organism re-established. The simplest solution of the problem is the occurrence of a sequestrating suppuration of the interlobular connective tissue round the cheesy lobule; this breaks down all the bridges which unite the dead with the living tissue. I have met with an example of this FIRST form of pulmonary phthisis in the person of a scrofulous child, seven years of age.* A lobule as big as a walnut had been converted into a cheesy lump, and lay, quite free, in a cavity of corresponding size, which was lined with a pyogenic membrane; the afferent bronchus, with the vessels, forming a pedicle by which it still continued attached. Beside it was a second cheesy lump of equal size, in an earlier stage of the same sequestrating process.

§ 442. SECONDLY, and far more usually, the suppurative sequestration does not take place until the zone of softening of the cheesy nodule approaches the circumference of the lobule; it seems as though the dormant activity of the connective tissue were first excited by the trifling putrefactive changes on the ulcerated surface, alluded to above. Reddish, highly-vascular granulations begin to sprout here and there from the walls of the cavity; and, where the cheesy matter has wholly disappeared, we can see that these granulations belong to a pyogenic membrane with which the entire cavity is lined. The latter yields a thick purulent secretion, and is very often the seat of small parenchymatous hæmorrhages, which may be readily explained by the softness of the granulation-tissue, the thinness of the capillary walls, and the persistence of the compensatory hyperæmia. The hæmorrhages leave a residue of brown and black pigment, often imparting a very singular appearance to the membrane. Notwithstanding all this, the membrane possesses all the virtues of a new texture, produced in the course of repair by the second intention; for there is no doubt that by its further metamorphosis into a fibroid cicatrix, the cavity may be completely healed—and the patient also—provided he be fortunate enough to possess only this one cavity. As a rule, indeed, the lung contains more than one such cavity, and a number of cheesy deposits in addition, so that the progress of the disease is more than sufficiently provided for. The formation of several vomicæ near one another gives rise to complicated excavations, the intervening septa being worn away till nothing is left of them beyond the larger vessels. In very protracted cases of phthisis, the whole upper lobe of one lung, or at all events its upper half, is often converted into a single large cavity, traversed by the obliterated branches of the pulmonary artery. The cavity is lined by a grey pyogenic membrane, which is reflected over the vessels, and is only interrupted here and there by more recent, red granulations, or by residual shreds of cheesy parenchyma.

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* The specimen is preserved in the collection of the Pathological Institute at Zürich.

§ 443. Pulmonary phthisis presents us with a THIRD and very rare set of anatomical appearances, when the reactive inflammation of the interlobular septa sets in early, taking the form of a hyperplastic proliferation of connective tissue. Broad bands of fibroid tissue are found traversing the entire organ; they are continuous with the thickened pulmonary pleura on the one hand, with the peribronchial and perivascular sheaths on the other. Every cavity remains independent of the rest; and when the alveolar parenchyma has wholly disappeared, we find in its place a number of comparatively small cavities, each lined with a smooth pyogenic membrane, and separated from its neighbours by a thick partition of fibroid tissue. The larger bronchi are usually found dilated and hypertrophied; so that I cannot help suspecting that this is one of the rare cases in which a hypertrophic bronchiectasy is secondarily complicated by catarrhal inflammation and caseation.

§ 444. FOURTHLY and lastly, we must return once more to acute phthisis (*Phthisis florida*). The rapid disintegration of the cheesy foci which occurs in this variety of phthisis, results from a suppurative liquefaction of all the connective tissue situated in the interior of the deposit; a suppurative liquefaction which sets in early enough to convert the major part of the alveolar parenchyma into a fluid—into pus—before the actual necrobiosis sets in; thus preparing the way for the softening which is about to ensue. This is the variety known as "purulent-ulcerative" (*eitrig-ulcerative*) to those who recognise the liquefaction of the cheesy deposit as a true abscess-formation. The further course of the disorder tends to justify this way of looking at it; the foci of softening, when they happen to be situated near the surface of the lung, not unfrequently burst into the pleural sac just like other abscesses, instead of voiding their contents through the afferent bronchi. A diffuse pleuritis with a copious purulent exudation forthwith ensues; should the cavity happen to communicate with the afferent bronchus likewise, the occurrence of pyopneumothorax is inevitable. I ought, however, to add that rupture into the pleural sac is a catastrophe which is always imminent in the case of ordinary vomicæ as well—a catastrophe which is only prevented by the previous occurrence of adhesive inflammation between the costal and the pulmonary pleuræ.

§ 445. Pulmonary concretions. I have hitherto alluded only to the softening of the cheesy lumps, by far the most common and important of the metamorphoses to which they are liable. The possible occurrence of calcification is merely an interesting curiosity in comparison. It is only when the cheesy nodules are small, that any further metamorphosis, especially softening, is absolutely prevented by an abundant deposit of calcic phosphate and carbonate—by a process of real petrifaction. It is in this way that pulmonary concretions (*calculi pulmonales*) originate; hard bodies from the size of a split pea downwards, with their surface either smooth, or beautifully lobulated like a mulberry. There are persons who suffer from frequent attacks of bronchial catarrh, and who now and then bring up a considerable number of these pulmonary concretions; their expulsion being attended by an exacerbation of febrile symptoms. It is obvious that the expulsion of these calculi can only be due to a sequestrating suppuration which they, as foreign bodies, excite around them. Another necessary condition for their removal is the simultaneous perforation of a bronchus of adequate size; for microscopical investigation affords conclusive proof that the concretions voided in *phthisis calculosa* are cheesy lobules of pulmonary tissue impregnated with calcareous matter. The elastic tissue, as well as the black pigment, are not in any way altered by the calcification; so that, by macerating the concretion in hydrochloric acid, we are always able to restore the entire areolar framework of several infundibula together with their alveoli. Bronchial calculi (*see* § 421) are far less common; they are invariably smooth, globular or elliptical, and occur singly or in groups in bronchiectatic cavities. Finally, we sometimes meet with encapsuled concretions disseminated throughout the lungs; in which case we may infer that the irritation they set up, though sufficient to cause a chronic overgrowth of the connective tissue immediately around them, was not intense enough to give rise to suppuration.

2. TUBERCULOSIS.

§ 446. Since the order we have chosen to adopt in treating of the diseases of the lungs rests not so much upon a systematic, as upon an etiological basis, we may be allowed to consider true tuberculosis of the lungs immediately after that disease with which it was so long classed, and with which it really has many very intimate points of contact.

We find miliary tubercles in the lungs, as in several other organs, occurring in two typical forms, which may be aptly termed "disseminated" and "localised" respectively.

§ 447. DISSEMINATED TUBERCULOSIS is always the sign of a constitutional disorder; for besides the lungs, we find other organs permeated by or studded with miliary tubercles, *e.g.* the liver, the serous sacs, the pia mater, the choroid. It is this almost invariable coincidence which justifies us in regarding the miliary nodules in the lungs as true tubercles, and not as accidental nodules of connective tissue, such as might be produced by the injection of minute particles of some chemically inert substance into the pulmonary artery. The disease usually affects children between three and seven years old; it is less common in adults. The entire lung, together with the pleura, is, as a rule, pretty uniformly studded with the miliary nodules; cases differ not so much in the degree of uniformity with which the tubercles are disseminated throughout the lungs, as in the total number of tubercles contained in them; this varies from one to twenty per square inch, either of superficial or of sectional area. As for the size of the individual nodules, this is undoubtedly liable to great variations; in some cases they are barely visible, or even quite undistinguishable by the unaided eye; in others, they attain the size of a stout pin's head, or even of a hemp-seed. The larger the nodule, the more likely is the actual tubercle to be surrounded by a circumscribed zone of parenchyma in a state of catarrhal inflammation, a circumstance to which we shall have to allude hereafter.

§ 448. These disseminated tubercles are situated in the connective tissue of the lungs. In single instances (*Deichler*), the miliary nodules are exclusively developed in the sheaths of the minute arteries and veins; more commonly, they spring up in the connective tissue between the lobules and infundibula. In texture, these nodules exactly resemble those which are simultaneously produced in other organs, such as the omentum or the pia mater. The larger ones may usually be shown to have been developed from several centres (fig. 131); *i.e.* they exhibit certain points in their interior, round which a portion of the tubercle-cells are concentrically grouped, while the remainder form bands which course between the component nodules. At the periphery of the tubercles, the swollen condition of the alveolar septa at their junction with the nodules, arrests our attention. It is clear that the process of morbid growth, when we are fortunate enough to detect it in mid-career, advances, not by an infiltration of the alveoli themselves, but by a swelling of their walls. The alveoli, unless matters are complicated by a catarrhal inflammation, are merely distorted and blocked up by the projection of the tubercles into their interior. In a tubercle as large as that which I have figured, a certain number of alveoli may indeed be obliterated; but their obliteration, and the consequent exclusion of air is accidental, and not, as in catarrhal inflammation, the main feature of the morbid change.

On examining the broad junctions between the alveolar septa and the tubercle—the little feet, so to say, which the growing nodule puts out—we invariably find the perivascular connective tissue—nay, even the walls of the vessels themselves—taking an active part in the proliferation. Fig. 131, *B*, shows this very beautifully; it is borrowed from *Colberg*. We see all the capillaries given off by an arteriole of considerable size, covered with masses of adherent corpuscles, which are, in all probability, descended from the corpuscular elements of the vascular wall itself.* The vessel here depicted has of course been torn from its natural connexions; we must imagine its environment to have been in a similar state of luxuriant proliferation.

§ 449. No catarrhal complication is to be observed in the alveoli adjoining the tubercles here figured (fig. 131, *A*); but I must add that such a complication is very usual, and that it often doubles the size of the miliary nodule. The combination of disseminated tuberculosis with a diffuse, perhaps even lobar, catarrhal pneumonia, is also met with; the tuberculosis may then be regarded as the predisposing cause of the inflammation.

§ 450. Having thus given an adequate definition of what may legitimately be called "tubercle" in the lungs, we may proceed to discuss the question, What share has tuberculosis in pulmonary phthisis? Mention has already been made of the fact that, owing to an insufficient limitation of the term "tubercle," phthisis and tuberculosis of the lungs have long been regarded as identical. We must beware, however, of running into the opposite extreme, and restricting the domain of tuberculosis within too narrow limits. Rather ought we to inquire, carefully and circumspectly, with which of the anatomical varieties of pulmonary phthisis (enumerated in § 433 *et seqq.*), a simultaneous development of miliary tubercles is found to be associated. A long series of special investigations has led me to the conclusion that it is only in a relatively small proportion of cases that miliary tuberculosis is wholly absent. I failed to discover it in two cases of cheesy infiltration running a rapid course with the formation of multiple foci of softening (*Phthisis florida*); I failed to discover it in the few cases of phthisis secondary to measles which came under my observation, particularly in one instance, where all the bronchioles of a certain (though not of the very lowest) order were in a state of ulcerative dilatation, and immediately surrounded by caseous pneumonia; simulating thereby the appearances of a uniformly disseminated miliary tuberculosis. As regards the remaining forms, in which the existence of miliary tubercles could be clearly demonstrated, I am inclined to believe in a relation of coexistence between the inflammation and the tuberculosis, similar to that with which we are familiar in "tuberculous" ulceration of mucous membranes. In the latter case, it is quite the exception to find the tubercles actually instrumental in the destructive process (Urinary passages); as a general rule, they are found in

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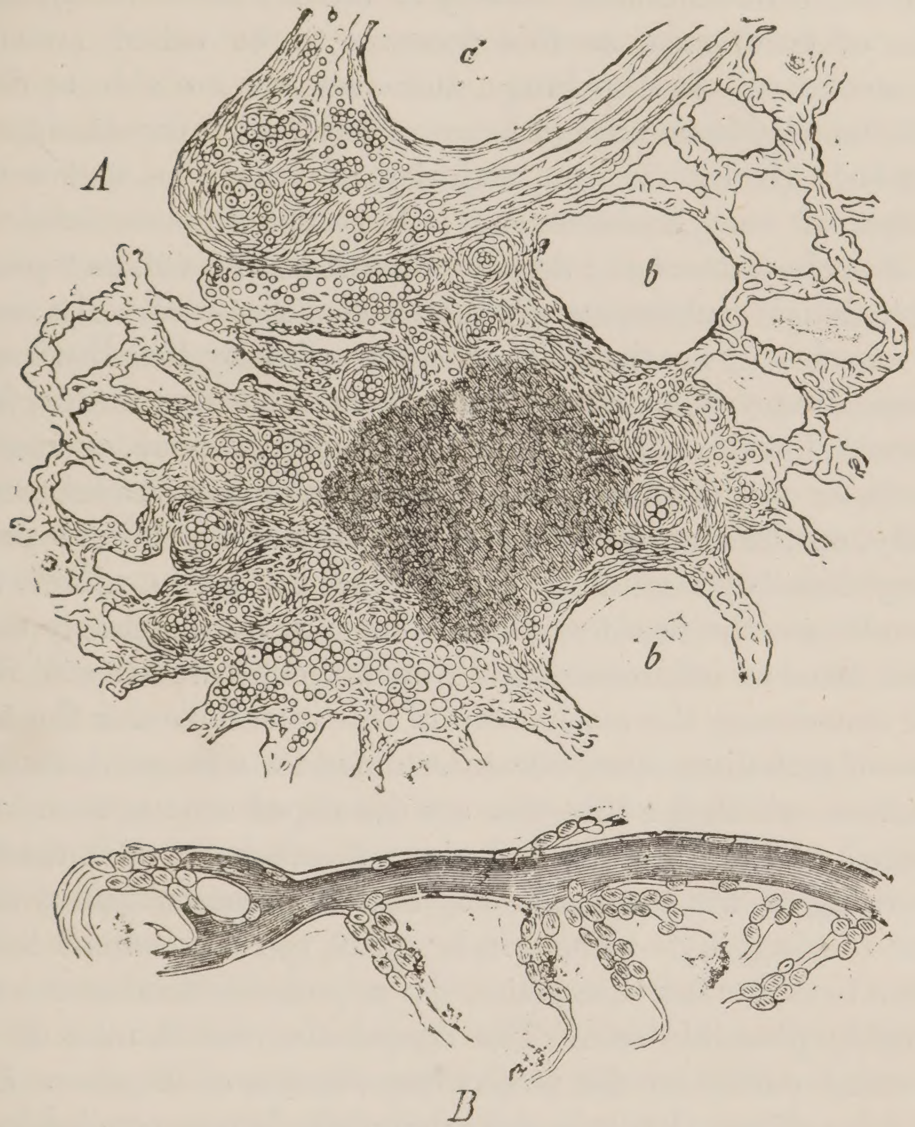
* *Cohnheim's* researches (*Virchow's* Archiv 40, p. 1) to which I shall return when describing croupous inflammation, allow us to regard these elements also as colourless corpuscles which have emigrated from the blood.

FIG. 131.



Miliary tubercle in the lung. *A.* Part of a small vessel seen in transverse section, in whose walls, as well as in the neighbouring connective tissue, corpuscular proliferation has occurred; the latter presenting itself to the naked eye as a white nodule. *a b.* Infundibula. $\frac{1}{100}$. *B.* An arteriole from its immediate neighbourhood, showing nuclear proliferation. After *Colberg.* $\frac{1}{300}$.

the immediate neighbourhood of, sometimes scattered through, the base and edges of the ulcer which derives its name from them (Intestine, Larynx); thus playing the part of a somewhat enigmatical complication, regarding whose connexion with the destructive process nothing is certainly known. In marked contrast to the disseminated variety of miliary tuberculosis, such a mode of occurrence as this deserves to be called LOCALISED TUBERCULOSIS. In the lungs, moreover, we are able to distinguish broadly between two forms of localised tuberculosis.

§ 451. In by far the majority of cases, we find a small number of very characteristic miliary nodules associated with the broncho-pneumonic deposits described in § 433 as "pseudo-tuberculous" (tubercular granulations of *Laennec*). An assiduous search will nearly always be rewarded by the discovery of the specific products, though sometimes in scanty number, in the interstitial or the parenchymatous connective tissue, or upon the vessels, or on the pleura and its inflammatory efflorescences, or, finally, on the mucous lining of the bronchi. Of late years a theory has been gaining ground, according to which these tubercles are the result of a local infection by the cheesy matter in the focus of inflammation. Now although we are still in the dark concerning the mechanism of this infection—for the hypothesis of embolism cannot be entertained for a moment, since the vessels on which the tubercles are developed are not found to be plugged at those points, and since it can be proved that any narrowing of the vessel is solely due to pressure from without, never to plugging—although, I repeat, the rationale of this infection is still under discussion, the hypothesis itself seems to me a highly plausible one. The favourable view I take of it is grounded partly on the recent experiments of *Hoffman*, *Lebert* and *Wyss*, *Klebs*, *Cohnheim* and others, who have succeeded in producing something at any rate very like tubercle by the inoculation of cheesy matter, partly on the frequent occurrence of miliary tubercles in the neighbourhood of solitary lumps of cheesy matter in the lungs, or of cheesy glands in the mediastinum or mesentery. A case fell under my notice quite lately, in which a child, whose organs were otherwise absolutely free from any trace of tubercle, presented miliary nodules in considerable numbers upon the pleural investment of the right lung, as well as on the corresponding surface of the costal pleura. Those on the pulmonary pleura were most crowded towards the lower border of the upper lobe, converging towards a thick, somewhat stellate patch lying just over an old cheesy deposit in the interior of the upper lobe, which had undergone softening at its centre, while the remainder of the lung was still quite healthy. These appearances very naturally suggested that the tubercles were a secondary product, due to metastasis from the old inflammatory deposit, round which the little nodules were so exclusively aggregated. But if we go on to inquire how the infection of the *costal* pleura was brought about, no one is likely to suppose a transfer of material particles to have taken place through the blood-vessels; on the contrary, it must be admitted on all hands, that the infection must needs have been propagated by contact with the already diseased pulmonary pleura.

§ 452. It is with much less confidence that I next proceed to enumerate among the varieties of "localised tuberculosis," a process which certainly presents, more than any other, the naked-eye characters of a dense aggregation of miliary nodules, and which, though undoubtedly distinct from catarrhal pneumonia, presents so many features of a non-tuberculous character in its minute structure, that I am inclined to hesitate before giving it a name.

In the immediate neighbourhood of a large cavity occupying the apex of one lung, we very often find an enormous number of nodules of uniform, and literally "miliary" dimensions, embedded in a parenchyma otherwise but little altered; these nodules are very tough and elastic, of a greyish, translucent colour which passes into a whiter tint at their centre. Should the section be a happy one, we further notice that the nodules are not scattered irregularly through the tissue, but according to a certain definite order, *e.g.* in branching lines, or in lines radiating from a central point where the nodules are most thickly set. The alveoli in the affected area are *not* filled up; the septa participate to some extent in the morbid growth, with which they blend; upon the whole, however, the parenchyma is rather squeezed, deprived of blood, and obliterated, than subjected to any of the various modes of decay alluded to above; the tissue may even be shown to contain air until the deposit of nodules monopolises all the available space. This brings about a condition which cannot indeed be called an "infiltration" in the narrower sense of the word, but which appears to hinder nutrition quite as effectually, and so to cause the dissolution and break-up of the deposit. The subsequent excavation invariably starts from a bronchus of considerable size, in whose walls the nodules have also managed to obtain a footing. It is in the peribronchial connective tissue more especially, that they form a continuous stratum; they also appear in the submucous tissue, and to a smaller extent in the mucosa itself; it is in the last of these that the destructive process begins with the formation of lenticular ulcers, which rapidly increase in superficial area and in depth.

§ 453. Microscopic examination of these nodules shows at a glance, that they consist in the main, not of granulation-tissue, but of a very tough and compact connective tissue. A hyaline, translucent, obviously very dense and rigid matrix, is partitioned out into a certain number of layers by anastomotic networks of stellate cells, which appear spindle-shaped in transverse section; these layers being concentrically grouped round a central nucleus of darker hue. Where the nodules lie close together, the peripheral layers of this connective tissue pass from one nodule to another; whole groups of nodules (from five to ten) may thus be combined to form a single nodule of larger size. We see at once, that two of the most striking properties of these nodules—those very properties which mainly induce us to regard them as tubercles—depend upon the presence of a tissue, which, *per se*, has nothing whatever to do with tuberculous formations. Let us now turn our whole attention to the central nucleus. Here at least, where the naked eye detects a yellowish-white opacity, we may possibly discover a miliary tubercle which may have surrounded itself with a capsule of connective tissue. The leading writers (among others *Rokitanski*, Lehrbuch, iii. 87) support this doctrine of "cystic" or "encysted" tubercles which was put forth even by *Bayle* and *Laennec;* on the other hand *Virchow* (Krankhafte Geschwülste) cannot find words strong enough to warn his readers against the fallacy of observation on which, in his opinion, this view is based. The nodules may be nothing more than bronchi seen in transverse section, bronchi with a thickened adventitia, bronchi whose mucous lining may have been altered by chronic catarrh or by a true "tubercular" process, and in which the superficial irritation has set up a reactive inflammation of the deeper layers of connective tissue, a "peribronchitis." This explanation is confirmed by the nearly invariable presence of a lumen in the centre of the nodule, which is otherwise peculiarly dark and opaque. We notice either a little stellate crevice, or a complete ring of a homogeneous, translucent substance, which cannot be more exactly defined in words, the ring being thrown into folds like the intima of a contracted artery (fig. 132). On the other hand, it must be admitted that in the larger bronchi, the peribronchial thickening is itself due to the presence of nodules, and that even in these nodules, which are situated in the very substance of the bronchial wall, the central lumina are also present. Again, the nodules are found in regions absolutely destitute of bronchi. They are peculiarly abundant in and upon the interlobular septa; and it was this very fact which first roused my attention to the singular coincidence between their arrangement, and the course of the lymphatic vessels.* The nodules occur in the pleura, in the connective tissue which invests the primary and secondary lobules, in the peribronchial and perivascular sheaths, finally in the mucous and submucous tissues of the respiratory tract itself, while they are less numerous in the parenchyma proper. A step farther brought me to the conclusion that the preformed canals from whose walls the miliary nodules grew, were no other than the lymphatics. The following are the details of the process :—

§ 454. At a certain point in, or rather for a very short part of its course, both the inner (epithelial) and the outer (connective tissue) tunics of a capillary lymphatic, undergo a progressive metamorphosis which leads to a considerable thickening of both coats, and results as a whole in the formation of a circumscribed, nodular enlargement. A luxuriant proliferation of the epithelial cells produces a pad of embryonic tissue which intrudes from all sides into the interior of the lymphatic channel, blocking it up till nothing is left beyond a small chink or fissure. On transverse section (fig. 132), the cells of which this pad consists are found to possess a radial arrangement; each ray seeming to correspond to one of the original parent-elements; corpuscles of a truly lymphatic character are seen alternating with epithelioid forms of larger size, abundantly furnished with protoplasm—such indeed as we habitually meet with in miliary tubercles also. In fairly sharp contrast to this radiating nucleus, is a peripheral layer whose elements are disposed concentrically. This is quite as thick as the first, but does not consist exclusively of cells, containing in addition, at least an equal quantity of homogeneous basis-substance. The lamellar disposition of the latter, together with a corresponding arrangement of the corpuscular elements which it contains, gives rise to the concentric appearance already referred to; here too, each little row of from two to seven cells, may be held to represent the progeny of a pre-existing connective-tissue corpuscle, though of course we cannot affirm this as confidently as in the case of proliferating cartilage.

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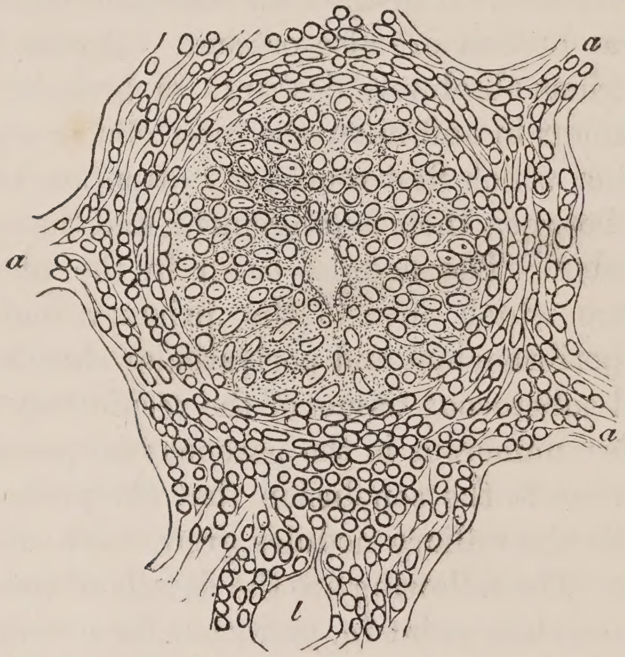
* I thus resume a hypothesis which *Virchow* once put forward, and afterwards let drop. In the meantime, *Klebs* has carried out the theory of the origin of miliary tubercles from the lymphatics.

Fig. 132.



A lymphatic vessel affected by *Lymphangitis tuberculosa*, seen in transverse section. *l*. Lumen of a vessel which is not as yet much altered; *a*. Alveolar septa at their origin from the degenerated lobular septum.

To get a good view of the appearances just described, it is necessary to cut very thin sections (according to the method laid down in § 365, *note*), employing, if possible, such nodules as are still isolated in the connective tissue of the septa. It is in these that we are first able to trace the connexion of the central lumen with a comparatively unaltered lymphatic trunk; here too, we can best observe the earliest stages in the development of the nodule. For the condition which I have described above lasts but a little while. A peculiar sclerosis of the central substance very speedily sets in, starting from one point or from several points at once, and obscuring the nucleus to such a degree as to render any discrimination of the individual cells utterly impracticable. True, the connective tissue of the cortical layer grows all the more distinct both in its texture and its composition; but then *its* nature has never been called in question. The issue rests upon our interpretation of the grey central opacity. Having got at the true nature of the process, what name shall we give it? We are not justified in going beyond the limits of a "lymphangitis nodosa." Should we add the epithet "tuberculosa," we should have to adopt the following train of reasoning: the miliary tubercle originates in the connective tissue; wherever the connective tissue happens to have a free surface, coated with an endothelium, the tubercle originates by preference from a proliferation of this endothelium. The miliary tubercle of the omentum (§ 283, fig. 108) affords the best proof of this. But the epithelial cells which line the lymphatics, as well as those of the serous membranes, belong to the category of endothelia; and as, moreover, the corpuscles resemble tubercle-cells in form, we may regard *lymphangitis nodosa* as a mere local modification of the ordinary development of tubercles.

3. PLEUROGENIC PNEUMONIA.

§ 455. Among the numerous combinations of pleurisy with pneumonia, it is not always easy to decide which is the primary, and which the secondary phenomenon. For the most part, the pleuritic inflammation is secondary to that of the pulmonary parenchyma. Thus we find pyæmic pleurisy resulting from embolic pneumonia; thus caseous pneumonia and tuberculosis nearly always excite acute and chronic pleurisy by way of complication; thus croupous pneumonia owes its old name of "pleuro-pneumonia" to the circumstance that when the disease has culminated in yellow hepatisation, a thin layer of lymph is almost always found upon the surface of the affected lobe, giving rise to the characteristic friction-sound heard over the thoracic walls. The converse is much less common. When discussing inflammation of the serous membranes, I made no allusion to the trifling fact that the outermost infundibula, those immediately beneath the inflamed pleura, are very commonly found occupied by a fibrinous exudation during pleurisy. This exudation undergoes resolution subsequently, not complicating the course of the disease any more than the slight pleurisy which accompanies croupous pneumonia complicates the latter disorder. In fact, it is only in the case of what is known as Pneumonia dissecans that we meet with an instance, and that on a very large scale, of the propagation of pleuritic inflammation to the lung. Pneumonia dissecans is an exceedingly rare disease in the human subject; it is more common in cattle, forming the anatomical groundwork of epidemic pleuro-pneumonia.

§ 456. Pneumonia dissecans is a suppurative inflammation—a suppurative liquefaction—of the septa of connective tissue which unite the great lobular divisions of the lung with one another. Their conversion into pus necessarily leads to a separation of the pulmonary lobules into their constituent parts; hence its very characteristic name. Even with the naked eye we can usually assure ourselves that it is the lymphatics passing from the pleural surface to the root of the lung through the septa, which are answerable for the extension of these inflammatory changes. If we strip off the pleuritic exudation from the surface of the lung, where it often forms a massive layer of purulent matter, we may see the lymphatic network distended by, and bathed in pus, encircling the secondary lobules with yellowish-white, varicose threads, and stretching downwards along the sides of the larger lobes, which have already become separated from one another. The dissection of the lung into its constituent lobes may be more or less completely carried out; as a rule, however, the fatal issue is so speedily arrived at, that the separation is only partially effected, or perhaps only indicated. We often find the septa infiltrated and brawny, and streaked here and there with pus; their thickness being accordingly increased to three or four times its normal standard.

4. Diseases caused by the Inhalation of Dust.

§ 457. It is only within the last ten years that it has been incontestably established, that particles of dust, suspended in the air we breathe, may penetrate from the bronchi and alveoli into the substance of the lungs, where they may either remain permanently embedded, or else be carried with the stream of lymph to the lymphatic glands at the root of the lung, where they are finally deposited. This series of phenomena had been suspected long before; the English physicians, above all, had explained the black lungs of their colliers on this theory; in Germany, on the other hand, it was opposed; and the opposition, led by *Virchow* and *Hasse*, has had at least one good result; it has compelled us to admit the possibility of an "autochthonous" origin of pulmonary pigment, besides its introduction into the lungs by inhalation; in the former case, it is derived from altered hæmatin; and this undoubtedly brings us nearer to the truth than if we were, with unjustifiable narrowness, to recognise only one possible mode of origin.

At that time I was myself employed in the Pathological Institute at Berlin, and took an active part in the minute investigation of that very specimen of black lung, which was furnished to the post-mortem theatre in the year 1860 from the clinical wards of Professor *Traube*, and in which the microscopic appearances of the inhaled particles of charcoal could be recognised beyond all possibility of cavil. Since then, the great object of all inquiries has been to ascertain the extent to which this fact, whose existence was thus established, might be applied; in the solution of this problem, *Zenker* has taken a leading part. At the present day, we distinguish between the following varieties of Pneumokoniosis (disease due to the inhalation of dust).

§ 458.—1. Anthracosis (inhalation of coal-dust). A great part of the black pigment which progressively accumulates in our respiratory organs with advancing age, seems really to consist of the carbonaceous matters we have inhaled. These are usually derived from the incomplete oxidation of wood, peat, coal, illuminating products and other combustible substances; suspended in the atmosphere as soot or smoke, they accompany the air into the respiratory passages, to whose moist walls they cling. The ultimate destiny of these exceedingly minute particles varies with the point at which they are arrested. Wherever the bronchial mucous membrane is lined with ciliated epithelium, the pigmentary particles cannot penetrate into the parenchyma. Together with the mucus that arrests them, they are propelled towards the glottis and ultimately got rid of, partly by the gradual operation of the cilia, partly by sudden efforts of coughing. If we separate the jaws of a frog, and sprinkle coal-dust over the upper wall of its pharynx, which is lined with ciliated epithelium, we may observe the forward movement of the black granules even with the naked eye; the phenomenon occurs in precisely the same way upon the mucous membrane of the respiratory tract in the human subject: so that when the son of the Muses finds his sputum "dirty" on the morning after a drinking-bout, he may console himself by recognising in this black matter, a portion of the lamp-black, &c., inhaled on the previous evening, which has been conveyed into his trachea during the night by ciliary movement, and made ready for expectoration. On examining such sputa under the microscope, we find most of the little black granules enclosed in round cells. The cells of the sputum, also known as mucus-corpuscles, are destitute of a membrane; and they have occupied the interval in taking up some of the solid particles (deposited in the mucus which surrounds them), following in this the analogy of the colourless blood-corpuscles.

Very different is the fate of those carbonaceous particles which have made their way into the alveolar parenchyma. Here of course, there is neither secretion of mucus, nor ciliary motion. The carbonaceous particles therefore remain provisionally quiescent, and afterwards penetrate into the soft tissue. To the question, how is this possible? where are the propelling forces? I would answer by directing the reader's attention in the first place to the great difficulty or even the impossibility of the solid particles being set free, after they have once stuck to the alveolar wall. Further, the great hardness and angularity which characterise the finest particles as well as the larger fragments of charcoal, render them peculiarly fitted for penetrating the soft tissues of the body, should the least impulse be communicated to them from any side. No sooner therefore have the particles of charcoal-dust entered the actual parenchyma of the lung, than they follow the general current of the extra-vascular nutrient fluid, together with which they tend ultimately to reach the lymphatic vessels. On their way, they must occasionally meet with corpuscular elements which have the power of permanently adopting small solid particles into their protoplasm. Foremost among such elements are the stellate corpuscles of the connective tissue; next, the migratory amœboid cells which are found in the connective tissue of the lungs as well as elsewhere, and which carry the black pigment with them wherever they may go. The residual portion, that which escapes being arrested by cells on its way to the lymphatics, is carried to the root of the lung and enters the lymphatic glands of the mediastinum. And here the granules meet with an insuperable obstacle to their farther progress; for the countless lymph-corpuscles with which the glands are stored, are ready to take up as many of the charcoal-particles as can, by any possibility, be accommodated in their protoplasm.

§ 459. This, of course, is only a theoretical view of the *probable* path of those carbonaceous particles which have penetrated as far as the alveolar parenchyma; but it is a view which agrees very closely with the actual distribution of the black pigment in the lungs. If we begin by inspecting the pulmonary surface in an individual of advanced age, we see the boundaries of adjoining lobules marked out by black lines and spots: a simple hand-lens enables us to trace finer ramifications penetrating from these lines and spots into the interior of the lobule and as far as the infundibular septa. In transverse sections, the accumulation of pigment is most apparent in the peribronchial and perivascular connective tissue. This mode of distribution corresponds pretty closely to that of the lymphatics, which originate in the infundibular septa, while the larger branches unite in the interlobular septa to form a network, which drains, partly into the pleural, partly into the peribronchial and perivascular lymph-paths. The pigment appears therefore to be chiefly deposited upon the brink of the lymph-stream. Microscopic examination enables us to see (wherever the pigmentation is least dense) the prominent share taken by the stellate corpuscles of the connective tissue in absorbing the pigment; while the larger lymph-paths are usually masked by an opaque cloud of black granules, which conceal all trace of structure.

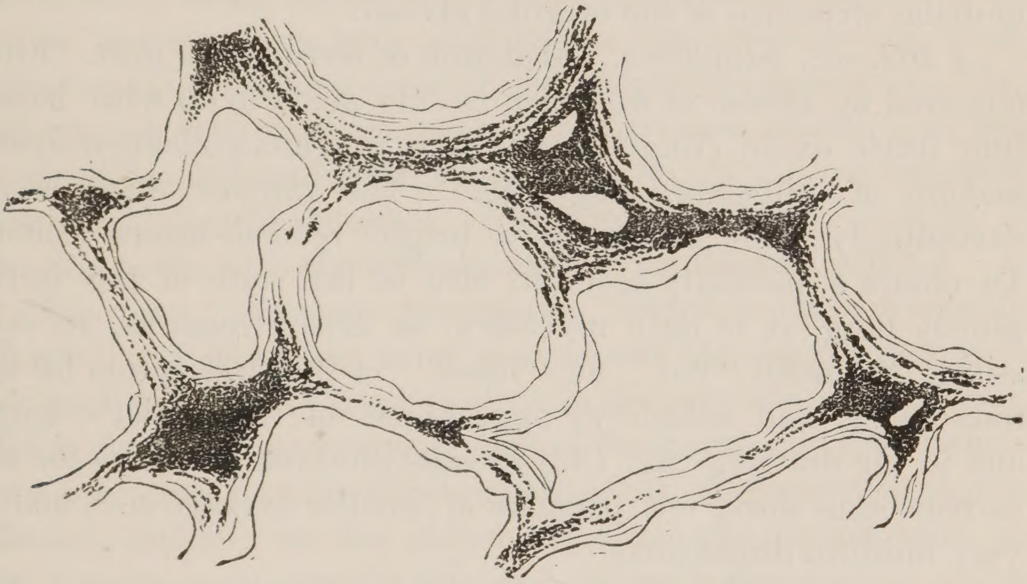
§ 460. The pigmentation of the lymphatic glands at the root of the lung is directly proportionate to that of the lungs themselves. Here too, we may see that the colouring-matter is first deposited on the very brink of the lymph-stream. For there exists a stage in the pigmentation of the lymphatic glands, during which only the capsule, the lymph-sinuses which surround the terminal nodules (Endkolben) and the medullary substance, are stained. These conditions render the structure of the glands exquisitely apparent even to the naked eye ; on more minute investigation we find the black granules situated partly in the delicate corpuscular networks which traverse the lymph-sinus, partly in a zone of lymph-corpuscles of varying width which fringes the sinus. At a later period, the pigment penetrates into every part of the gland as well; all appearance of structure vanishes, giving place to a uniform deep-black staining, which is associated with a moderate enlargement of the gland. A still more advanced stage of the metamorphosis will be described in the ensuing section.

§ 461. From the above form of anthracosis, which may almost be termed physiological, it is but a step to the anthracosis of coal-heavers and colliers. The coal in this instance makes its way into the air-passages, not only in the form of fine dust, but also in coarser and even tolerably large particles, readily apparent to the naked eye. In the juice squeezed from the parenchyma of *Traube's* lung (alluded to above), I found one of the "dotted cells" of coniferous wood entirely carbonised, but in which I was able to count seven pores close together. This particle of charcoal-dust equalled half the diameter of an alveolus. Of course, particles of this size do not penetrate into the parenchyma of the lung ; sooner or later they are always expelled with the sputa. Nevertheless, the particles which actually succeed in penetrating the tissues are considerably larger than those in the common form of black lung ; they exhibit very distinctly the sharp and angular projections which render them so apt for penetration. Splinters of wood-charcoal are especially characterised by possessing thorny processes, and by their singular colour, which appears ruby-red in thin layers by transmitted light. The pulmonary parenchyma is uniformly saturated with this pigment.

Every layer of connective tissue, in the alveolar and infundibular, as well as in the interlobular septa, contains a central deposit of charcoal-particles of considerable size, fringed by a scantier accumulation at its edges (fig. 133). All the cells, whether round, stellate, or spindle-shaped, are loaded with fine black granules; here and there we come across a particle of larger size embedded in the substance of a small round cell; these are most common in the sputum.

It is obvious that an importation of foreign bodies (which must give rise at the very least to mechanical irritation), and that in such quantities, cannot but have the most injurious effect upon the respiratory organs. Accordingly we find it followed in some cases by bronchial catarrh with muco-purulent expectoration, leading to emphysema; more rarely, it sets up changes of an inflammatory kind in the parenchyma, which are still in need of more thorough investigation. Older observers (*Thomson*, 1826) describe partial consolidations of the lung-tissue, with the formation of small cavities filled with an inky fluid; roughly speaking, therefore, lobular catarrhal pneumonia with imminent signs of passing into phthisis.

Fig. 133.



Anthracosis. Inhaled coal-dust in the alveolar septa of the lung. $\frac{1}{300}$.

The bronchial glands are also much involved in the anthracosis of colliers; and here the inflammatory reaction of the parenchyma commonly attains very marked proportions. I have twice seen the ordinary physiological anthracosis followed by suppuration in a gland, which afterwards opened into a main bronchus; this complication is more common in the anthracosis of colliers. An almost invariable phenomenon is a gradual thickening and condensation of the connective tissue in the affected gland, which gradually but surely entails its total obsolescence. Not only does the capsule become thickened, but the delicate trabeculæ which bridge over the lymph-sinuses and support the lymphatic tubes and follicles, also undergo sclerosis. The lymph-corpuscles are broken down; and ultimately nothing is left but a mass of fibrillar connective tissue whose concentric arrangement serves as a memorial of the globular structure of the original alveoli.

§ 462.—2. Siderosis. Inhalation of ferruginous dust. First observed by *Zenker* in workmen having much to do with handling ferric oxide (English red); *e.g.* in glass-polishers, dyers, makers of gilt-paper bags, &c. The inhaled dust is an exceedingly fine powder of a bright reddish-brown colour. To obtain a perfectly accurate idea of the state of the ferruginous lung, it is only necessary, as *Zenker* remarks, to substitute the word "red" for "black" in the description of the microscopic and naked-eye appearances of the collier's lung; and in the drawing (fig. 133) to substitute red particles for the carbonaceous dust, red particles of smaller average size, and of very uniform dimensions.

The consecutive changes consist partly in a catarrhal disorder of the bronchial mucous membrane, partly in certain multiple, lobular affections, which are termed by *Zenker* "indurative interstitial consolidations." An overgrowth of the interstitial connective tissue "obliterates the elastic tissue while sparing a vessel here and there, and leads at the same time, in some way not yet understood, to obliteration of the alveolar cavities, substituting a solid fibroid tissue for the spongy texture of the lung." Scattered throughout the entire organ we accordingly find greyish, transparent nodules, tough and rounded, varying in size from a pin's head to a pea, more or less closely aggregated, which clearly represent the starting-point of an excavation which is taking place simultaneously. To my mind, these appearances agree too closely with those of the variety of "localised tuberculosis" described in § 452, to allow of my regarding the coincidence as merely accidental; but I have no wish to interfere in any way with the independent judgment of my readers.

3. Concerning the inhalation of other kinds of dust, and especially of flint-dust, our knowledge is still very imperfect. *Kussmaul* and *Schmidt* found, after incinerating the lungs of a stone-cutter, that the ash contained three times as much silica as usual.

5. CROUPOUS PNEUMONIA.

§ 463. Croupous Pneumonia is one of the most common of the diseases which affect the lungs; its symptoms, its course, its issues, are therefore very well known; and yet we are more ignorant of its etiology than of that of any of its fellows. For although several most trustworthy observations enable us to put down cold as its usual cause, this gives us no insight into the mode in which the chill operates. For what has partial chilling of the skin to do with the inflammation of an internal organ?

The term "croupous pneumonia," which is now universally adopted, and which has taken the place of the older names, such as "peripneumonia," has its origin in the very obvious analogies which the disease presents to croup of the larynx and the trachea. In either case, a solid fibrinous exudation is deposited on the affected surface; in the latter, on a mucous membrane; in the former, upon the alveolar and infundibular surface. The intermediate part of the respiratory tract, the larger and smaller bronchi, may be involved both in the laryngeal and in the parenchymatous variety of croup. The fibrinous exudation usually forms solid cylinders (solid because of the narrow calibre of the tubes), which bifurcate repeatedly, corresponding to the bifurcations of the bronchi, and which retain their arborescent and branching form when they are expectorated. It is self-evident that this croupous bronchitis presents a high degree of clinical interest only when associated with laryngeal croup; while in the parenchymatous disorder, it matters little whether the bronchi do or do not admit air into a parenchyma which is, in any case, incapable of fulfilling its respiratory function. Croupous exudations are sometimes, though very rarely, confined to the bronchi. A young man in the neighbourhood of Zürich suffered for several consecutive years from a disease attended by febrile disturbance and extreme dyspnœa, which used to terminate by the expectoration of a large number of bronchial casts. Those which I received for examination must have come from bronchi of medium size. Of course the prognosis in this case depended on the degree to which the process extended on each occasion. (Cf. *Biermer* in *Virchow's* Handb. der speciellen Pathol. u. Therapie, i. Abth. p. 714.) But this is a digression.

§ 464. The oldest theory of pneumonia held it to consist in a swelling of the parenchyma. It was based on the roughest appreciation of the changes which had occurred, without any misgiving that they were situated less in the parenchyma than in the cavities which it enclosed. *Laelius de Fonte* compared the inflamed lung, mainly on the ground of its consistency, perhaps too on account of its colour, to liver, terming its state one of "hepatisation." He was thus the founder of our present nomenclature. We go beyond him however, in distinguishing between a red and a yellow hepatisation, adding a preliminary stage to these two principal stages of the inflammation (stage of congestion, *engouement*), and a terminal stage (that of purulent infiltration and resolution).

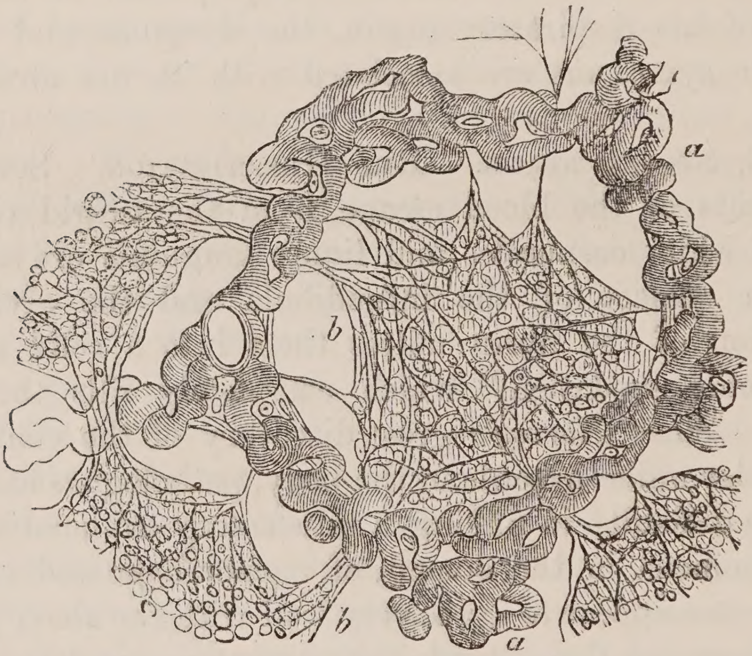
Croupous pneumonia affords the most brilliant and precise example of the way in which a histological series, whose individual members are necessarily evolved from one another in a certain order, can be made to explain on the one hand the naked-eye alterations in an organ, while on the other it elucidates the physical signs and functional disturbances to which the disease gives rise. We will try to follow out this proposition in detail by supplementing our account of the "histology" of each successive stage by a statement of the concomitant phenomena in those categories, which are, for our purpose, of subordinate importance.

§ 465. FIRST STAGE. CONGESTION. All the vessels of a large segment of the lung (usually of an entire lobe) are gorged with blood. Fine sections from small pieces hardened in *Müller's* solution and then in alcohol, show the surprisingly turgid and tortuous condition of the capillaries. They belly into the interior of the alveoli, which they visibly narrow. The subsequent exudation and extravasation are ushered in by the effusion of a viscid fluid, rich in albumen. Here and there, particularly in the interlobular and the subpleural connective tissue, minute punctiform hæmorrhages are already seen to have occurred.

The affected part of the lung is recognised by its red colour; the finger appreciates a marked loss of elasticity, an increased hardness, density and weight, due to its containing less air than usual. What air it still contains may be squeezed to and fro, the viscid fluid above referred to preventing its escape. Both the inspiratory and the expiratory efforts are opposed by this fluid, as is shown by the fine crepitation heard over the thoracic wall; functionally, the affected part is, even at this stage, as good as non-existent; and inasmuch as the patient is not yet habituated to the vicarious employment of the healthy residue of his respiratory organ, the dyspnœa, and whatever subjective symptoms are associated with it, are already most intense.

§ 466. SECOND STAGE. RED HEPATISATION. Some of the constituents of the blood escape from the turgid capillaries. Red and white corpuscles and liquor sanguinis are set free on the inner surface of the infundibula and the alveoli; the coagulation of the fibrin unites them into a solid mass, the "pneumonic exudation," which completely fills the alveolar cavities. Since *Harvey's* great discovery of the continuity of the vascular walls throughout the body, pathologists have always had some difficulty in finding a satisfactory explanation of certain phenomena in the domain of hæmorrhage and exudation, which do not appear to agree very well with the above principle. Foremost among these stands the pneumonic exudation. A bit of recently hepatised lung, injected from the pulmonary artery with gelatine and Prussian blue, is hardened, and then cut up into fine sections. In these sections (fig. 134), the alveolar walls exhibit precisely the same appearances as in a perfectly sound lung (*a*); we see the same scanty number of intervascular and capillary nuclei, the same superficial layer of scattered, rudimentary nuclei which we regard as the residue of the alveolar epithelium, all in their usual state. And yet the alveolar cavity is occupied by a finely-fibrillated coagulum (*b*) which encloses a number of red and colourless cells. These elements must therefore have come directly from the vessels; they must have penetrated their walls, even though no trace of an abnormal opening can be discovered. We, who have laboured long in the track of *Virchow* to assign the plastic exudation of the humoral pathologists exclusively to a local proliferation of the connective tissue, must feel convinced in the face of these appearances that our doctrine needs very considerable modification and restriction. *Cohnheim* (*l.c.*) has already laid a secure foundation for the new theory by his thorough investigation of the inflammatory process as it occurs in the mesentery of the frog. He has shown us, that in proportion as the circulation of the blood through the dilated veins and capillaries grows slower, the colourless corpuscles adhere to the walls of the vessels, and then emigrate through minute, preformed stigmata. This must accordingly be regarded as the way in which the pneumonic exudation is produced. The composition of the infiltrated matters varies within wide limits. The red blood-corpuscles are never wholly absent; in one case however they make up but a fractional part of the corpuscular elements present, while in another they may amount to double the number of the colourless corpuscles; in a few rare cases they accumulate in such enormous quantities that we may fairly ask whether the "exudation" ought not rather to be termed an "extravasation."

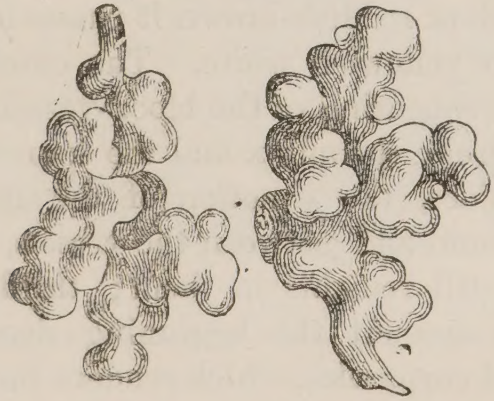
FIG. 134.



Recent croupous pneumonia. *a.* Alveolar septa; capillaries injected; *b.* The exudation. $\frac{1}{30}$.

This "hæmorrhagic character" of the exudation stamps itself upon the whole second stage of the pneumonia. We are reminded of it by the "damson-cheese" coloured sputa of the patient, by the epithet "red" hepatisation. Indeed the decidedly red, liver-like coloration of the infiltrated part of the lung ought rather to be ascribed to the blood which is extravasated, than to that contained in the vessels; since the quantity of the latter stands in a nearly inverse proportion to the amount of the exudation, and is therefore less at this stage than *e.g.* during that of congestion. The greater solidity and weight of the hepatised lung, the total exclusion of air, are due to the occupation of the last residue of the infundibular and alveolar cavities by solid matter. On scraping the cut surface of the lung with the knife, and holding it up to the light, we can see the small plugs of exudation protruding from the surface in the form of rounded granules, which may also be detected by the finger. We call this the "granular" condition of the pneumonic lung (fig. 135). Through this dense parenchyma, which is really very like liver, the inspiratory murmur, caused by the passage of air through the trachea and larger bronchi, is propagated without any alteration in its pitch to the ear of the physician, applied to the wall of the chest. We hear "bronchial breathing," mingled at most with a few bubbles of coarse crepitation, but no longer masked and altered by the vesicular murmur or by fine crepitation. The sound on percussion is

FIG. 135.



Plugs of exudation, got by scraping the granular cut surface of a hepatised lung. They are well adapted to show the form of the infundibular cavities, in which they are moulded. Cf. § 411. $\frac{1}{30}$.

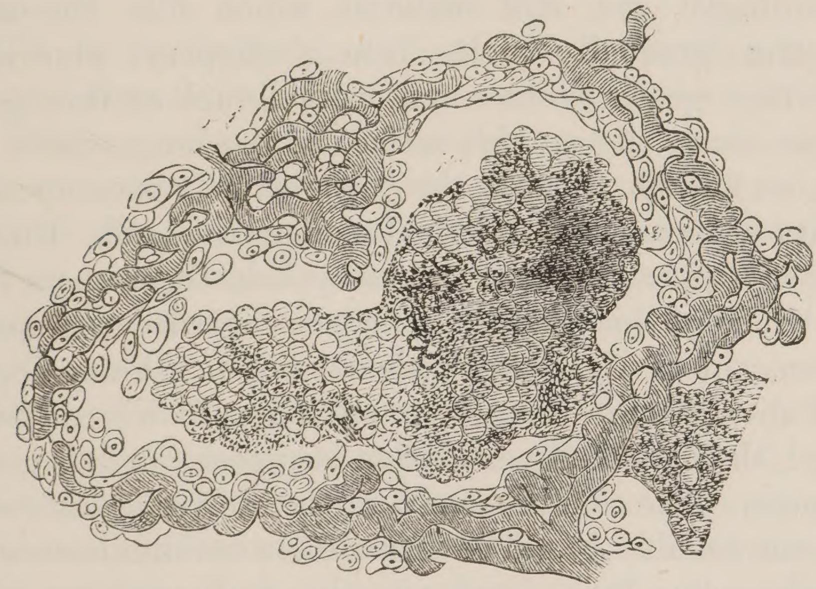
completely dull; the extent of consolidation may be determined to within half a centimetre.

§ 467. Third Stage. Yellow Hepatisation. Red hepatisation, as we have seen, occurs quite independently of the proper parenchyma of the lung; the stage which immediately succeeds it is characterised by the onset of textural changes in the parenchyma itself. That luxuriant proliferation of the corpuscular elements of the connective tissue and epithelium of the alveolar parenchyma, which we look for in vain in fig. 134, is strikingly apparent in fig. 136. Masses of young cells are everywhere seen in the interstices between the vessels; the whole internal surface is lined with several layers of epithelial elements which are abundantly intermingled with lymph corpuscles. Here, in fact, we have the signs of a true catarrhal inflammation; this is a point to which we shall return more particularly hereafter. Now the parenchymatous infiltration gives rise in the first place to a further increase in the bulk, the weight and the density of the inflamed lung; the "granular" appearance, owing to the swollen condition of the septa, is less marked. The most striking feature however, is the change of colour; from a dark reddish-brown it passes into reddish-yellow and finally into yellowish white. The chief cause of this is undoubtedly the squeezing of the blood-vessels by the additional infiltration, whereby the afflux and the transit of the blood are hindered. Besides, the situation of the infiltrated material immediately around and between the vessels, masks the colour of what blood still remains in them; thirdly and lastly, we must take into account the beginning decolorisation of the extravasated red corpuscles, which renders the infiltration paler, and allows the whitish, pus-like tint of the colourless corpuscles to prevail.

It would be a great mistake to suppose that the hepatised lung is as anæmic during life as we find it after death. I have invariably succeeded, without any great exertion, in completely injecting lungs in this stage of consolidation, even when they contained no blood at all on their removal from the body. This amounts to saying that the soft and elastic reaction exerted upon the pulmonary capillaries by the exudation, is overcome by the heart's energy during life, but suffices, when the heart grows feeble and its contractions finally cease, to squeeze the blood out of the capillaries and to accumulate it, during the general post-mortem settlement, either in the heart or the great veins.

§ 468. Fourth Stage. Purulent Infiltration. Resolution. Just as the stage of yellow hepatisation is ushered in by an alteration in the parenchyma, so the final stage of pneumonia is ushered in by a metamorphosis of the exudation. For while the parenchyma continues for a time in a state of purulent catarrh, the connexion of the exudation with the alveolar surface, which had hitherto maintained itself, is everywhere dissolved; the fine threads of fibrin, by which the exuded matter is seen (in fig. 134) to be moored to the alveolar wall, melt away, together with the rest of the fibrin, into a soft amorphous jelly, which encloses the colourless corpuscles, and what there is of the red ones, forming a little spherule which lies free in the interior of the alveolus (fig. 136). I think it probable that this jelly-like substance also takes up a number of those elements which are derived from the alveolar wall; I think this because it usually contains a quantity of granular, black pigment, which corresponds exactly in its characters to the pigment of the lungs. This pigment (*see* fig. 133) was formerly situated in the lacunæ and the corpuscles of the pulmonary connective tissue, and can only have got to the free surface by the spontaneous migration or passive "floating-out" of the cells which contained it.

Fig. 136.



Croupous pneumonia in a later stage of its evolution. Melting of the exudation. Catarrhal desquamation of the alveolar wall. $\frac{1}{300}$.

As regards the chemistry of the metamorphosis which the fibrin undergoes, I have already (§ 39) decided in favour of its being a mucous transformation. I grounded my opinion on the altered reaction of the exudation to acetic acid. During the stage of red hepatisation, the addition of acetic acid serves only to clear up the exudation and to dissolve the threads of fibrin; it now gives rise to a distinct precipitate of mucin. It must not be forgotten, however, that this mucin, which we find in the later stages of pneumonia, may possibly be derived from another source as well; it may originate *e.g.* by a mucous metamorphosis of the corpuscular elements, while on the other hand, the fibrin may have passed into a soluble modification, which need not necessarily be identical with mucus.

Accordingly the stiff material which fills the alveolar parenchyma gradually melts into a slippery, mucoid substance, which grows thinner and more liquid as time goes on. If we now scrape the greyish surface of the lung, which is still anæmic, we find no trace of the "granular" appearance, while a quantity of purulent fluid trickles along the knife. Bits of the lung are so slippery that we can hardly hold them in our fingers.

The whole of this final stage may be regarded as preparatory to the removal of the pneumonic exudation. Fatty degeneration and absorption of the *débris* contributes to this end but very partially; the bulk of the exudation is expectorated, is got rid of in the sputa. The conditions are in themselves as unfavourable as they can possibly be. The infundibula communicate with the afferent bronchus by a comparatively small opening. In the fibrinous casts (fig. 135) the pedicle *a* represents the calibre of this aperture, through which the whole fruit hanging from this stalk must make its way. It is obvious that this can only occur if the mass has entirely lost its original stiffness, if it has passed into a semi-fluid condition. In that case a violent expiratory effort may suffice to dislodge the plug from the narrow opening, and so to rid the infundibulum of its morbid contents. As a rule, the evacuation is preceded by a complete liquefaction of the exudation into "muco-pus;" for casts of the infundibula are, upon the whole, but rarely met with in the *sputum coctum* of pneumonic patients.

§ 469. As the expulsion of the alveolar contents proceeds, the anæmia remits; nay, the blood usually returns to the lung with intensified energy, so that the affected part appears rather of a deeper than a paler red in comparison with the healthy remainder of the organ, when the air is once more admitted freely into every part of it. This is due to a certain atony of the contractile and elastic elements of the tissue, due to the protracted and excessive disturbance of nutrition. This atony may be so considerable, even during the stage of resolution, as to allow the parenchyma underneath the pleura to be crushed by a very trifling squeeze. The cavity thus formed speedily fills with pus, and simulates a subpleural abscess. The loss of elasticity continues for a long time after the patient's recovery, yielding ultimately and very gradually to the improved nutrition of the parts; this is a circumstance the practitioner ought never to forget.

§ 470. In the foregoing sections I have described the typical course of inflammation of the lungs, whether it be restricted to a single lobe, or, as more frequently happens, involving several lobes in succession or even simultaneously. I have only hinted casually at the points where the disorder may deviate from its normal course; I now retrace my steps, in order to follow up those deviations more completely. They constitute the VARIETIES and ABNORMAL TERMINATIONS of pneumonia.

§ 471. A. Termination in GANGRENE. There are two principal causes which predispose a portion of inflamed and infiltrated lung-tissue to mortify. One of these is the presence of a few dilated bronchi, filled with putrid secretion, in the interior of the consolidated lobe. And here the bronchiectasy itself may usually be regarded as the true cause of the inflammation; and we may conclude that the putrid character of the subsequent metamorphosis of the infiltration is immediately derived from the putrid contents of the dilated bronchi.

Widely different are those cases of pulmonary gangrene, in which the putrid element is, so to say, "autochthonous." In such cases I have found that the "hæmorrhagic" element predominates in the stage of exudation. We shall hereafter become acquainted with circumscribed gangrene of the lung as the typical issue of hæmorrhagic infarction. In the latter case, the alveoli are actually filled with clotted blood; the circulation is completely arrested; and since we know that no substance is more prone to undergo putrefactive changes, under conditions otherwise favourable to them, than coagulated blood, we can readily see how gangrene must *necessarily* result from hæmorrhagic infarction. There are some pneumonic exudations however, in which the red corpuscles and fibrin predominate so greatly, that they differ but little from hæmorrhagic infarctions, and might even perplex an inexperienced observer. Hence we must not be surprised to find like causes followed by like effects, to find gangrene occurring in this as in the previous instance.

In connexion with the phenomena of gangrene, the share taken by vegetable parasites in the putrefactive changes has been much studied of late. According to *Leyden* and *Jaffe* the yellowish-white, pulpy lumps, varying in size from a milletseed to a bean, with a smooth surface and a peculiarly offensive odour, which are found in the sputa of patients suffering from pulmonary gangrene, consist of an immense quantity of minute granules and short, staff-shaped bodies, which exhibit lively rotatory movements on the addition of a little water, together with a number of minute oil-globules, crystals of fatty matter, pigment-granules and elastic fibres. In their opinion, we have to do with the sporules of a fungus, the progeny of the *Leptothrix buccalis*, which infests the mouth. They believe that the germs of this fungus are continually being drawn into the respiratory passages in large numbers ; but that they only proceed to multiply and develope when they find a suitable nidus in putrid matter, in a stagnant and decomposing fluid (Bronchiectasy). The most recent investigations of *J. Lüders* render it quite unnecessary to assume any transmission along the air-passages to account for the presence of the germs; these exist everywhere as quiescent vibrios, and hold themselves in readiness to undergo further development when the medium in which they are suspended begins to putrefy. The presence of these quiescent vibrios has actually been demonstrated in the blood; it has been shown moreover, that they are converted into active vibrios as soon as the blood dies.*

In conclusion, the phenomena of pulmonary gangrene are made up of the processes attending the putrefaction of the blood, the corpuscular protoplasm, the gelatigenous and the elastic tissues, as described in § § 11 and 19. In the diffuse variety of gangrene a considerable tract of parenchyma is converted into a greyish-green, eminently fœtid pulp, in which the more resistant structures, particularly the walls of the vessels with the bundles of elastic fibres which are attached to them, may be recognised for a long time after all the remaining elements of structure are broken up. Here and there, by the partial expectoration of the gangrenous sanies, cavities are produced, with ragged and shreddy walls. The mortified part, at its periphery, passes very gradually into recently hepatised lung-tissue, into a fresh pneumonic infiltration, obviously excited by the presence of the gangrenous part itself. It is only when the gangrene is extremely limited, and particularly when it makes its first appearance at a comparatively late stage of the disease, after a powerful reaction on the part of the parenchyma has already set in, that there is any chance of recovery; when this does occur, it is brought about by the ordinary means. We shall say more about it when we come to speak of circumscribed gangrene.

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* The author's views on this point have changed since the above was written. Cf. § 24, which has been altered since the publication of the second German edition ; the alteration is incorporated with the present translation.—Tr.

§ 472. B. Termination in PHTHISIS. When speaking of yellow hepatisation I called attention to the well-marked catarrhal state of the alveolar walls, which respond to the inflammatory stimulus by a productive activity of their corpuscular elements. The epithelium behaves just as it does in catarrhal pneumonia. It yields large, round or polygonal cells, rich in protoplasm, which mingle with the other contents of the alveoli. As a general rule, this homologous proliferation of epithelium is only just observable, and subsides in proportion as pus-corpuscles are produced, in conjunction with a marked serous œdema of the affected part. Cases occur, however, in which the croupous exudation may be said to exist only for the purpose of ushering in a true catarrhal pneumonia; in which the fibrinous exudation is speedily enclosed in a dry secretion from the alveolar wall, consisting mainly of cells, together with which it then falls a prey to necrobiosis. Vainly does the physician await the resolution of the pneumonic consolidation; he is at last compelled to admit that the case is one of "acute" caseous pneumonia. Its further progress differs in no respect from the usual course of broncho-pneumonic phthisis.

§ 473. c. Termination in Abscess. This also is due to changes in the parenchyma, not in the exudation. It threatens to occur whenever the corpuscular proliferation in the alveolar wall is not confined within its usual limits, when it is excessive in amount, and causes the disintegration and liquefaction of the interstitial connective tissue to which the form and consistency of the entire structure are due. Small cavities are first produced, filled with pus and the *débris* of the pulmonary tissues. These may coalesce by softening of the intermediate partitions, forming abscesses of larger size; this may go on until one-half or even the whole of a lobe is occupied by a single abscess of great size. But the reactive inflammation at the periphery of the deposit may at any time result in the formation of a stout layer of embryonic tissue which arrests the further progress of the morbid change; this at once takes up the position of a granulating surface towards the abscess; it continues for a time to secrete pus, and finally lessens the abscess-cavity by gradually undergoing contraction.

6. Embolic Pneumonia.

§ 474. The changes in the pulmonary parenchyma excited by the introduction of solid particles into the current of the lesser circulation, vary, as we know from experiment, with the size of the particles and still more with their physico-chemical properties; now in human pathology, so far as we are at present aware, such particles are always of one sort. Inflammation and suppuration have occurred somewhere in the body; caused by an operation-wound, by a fracture, by parturition, &c. The veins which traverse the affected part are filled with thrombi. The thrombosis extends into the larger systemic trunks; here the clot softens and is broken up; the fragments are carried through the right heart into the pulmonary artery, and wedged into branches of corresponding size (§§ 194, 196, *et seqq.*). Now these emboli have powerfully irritant properties. The entire process assumes the character of a septic inflammation; due less to the chemical products which might result from the decomposition of albuminous compounds, than to certain ferments—perhaps to the vibrios which are always present in large numbers. For whereas the injection of neutral substances—*e.g.* of pellets of wax—into the pulmonary artery, is never followed by anything more than a sort of indurative inflammation, in the case which we are now considering, suppuration is an inevitable, necrosis a very common event. Partly because of this constant "issue in suppuration," partly because of its secondary character, the embolic form of pneumonia has come to be known as "metastatic abscess."

§ 475. If, as not seldom happens, we have an opportunity of studying the first beginnings of the inflammatory process side by side with its more advanced stages, we are chiefly struck with the deep red colour, the swollen and consolidated appearance of a sharply circumscribed, wedge-shaped segment of the lung. The plugging of the afferent artery (fig. 137, A) has caused so intense a degree of primarily passive congestion within the area of its distribution, that the overloaded capillaries have given way at various points, and a large number of red corpuscles have escaped into the alveoli together with the exudation. This HÆMORRHAGIC TRANSUDATION, as I would term it, in contradistinction to inflammatory exudation on the one hand, to extravasation on the other, is merely a preliminary to the actual inflammation; it is the first result of the embolism, and constitutes, together with this, the source of irritation against which the organism reacts by means of the inflammation proper; the latter accordingly appears as something superadded or secondary. The larger the quantity of blood poured out in consequence of the primary lesion, the more likely is actual stasis to result from retardation of the current through the capillaries, the more marked is the subsequent tendency to gangrene; for stasis is synonymous with death, and, as I have already remarked, stagnant blood, when contained in a moist cavity communicating with the atmosphere, is peculiarly liable to undergo putrefactive decomposition. Inflammation and proliferation are quite as much in need of a continued renewal of the circulating fluid, as healthy nutrition; hence inflammation and proliferation may very possibly not occur at all in the centre of the affected part; and this serves to explain the great variety of the anatomical appearances in the later stages, a variety which is always very striking.

§ 476. The INFLAMMATION itself presents the typical characters of a purulent infiltration followed by abscess. The pus-corpuscles undoubtedly originate in the connective tissue of the alveolar and infundibular septa. From hence they migrate to the free surface, gradually taking up the space destined for the reception of air. When they have done this, the affected part presents the features of a tolerably complete hepatisation; on its cut surface, the naked eye can readily distinguish a delicate tracery of red lines and circles, upon a greyish ground. The grey ground is the purulent infiltration, the red lines are the alveolar septa, whose vessels are still pervious and full of blood. On squeezing out some of the exudation and examining it under the microscope, we find a number of largish cells mixed up with the ordinary pus-corpuscles, which are here for the most part aggregated into spheroidal clusters; the larger cells I believe to be more nearly related to the alveolar epithelia, partly because they are very like the cells in catarrhal pneumonia, partly because they often exhibit the phenomena of endogenous proliferation.

FIG. 137.

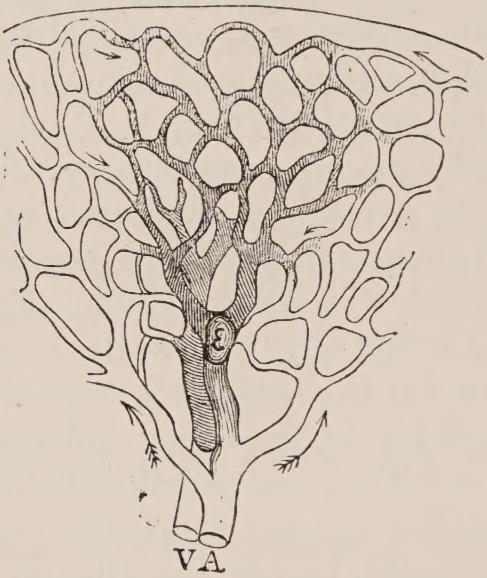


Diagram of embolic congestion of the lung. A. Small artery, plugged at E by an embolus. V. Small vein filled with a clot which extends as far as its trunk. The shaded portion of the capillary network is the area of distribution of the artery, in a state of passive congestion, and about to be the seat of a hæmorrhagic exudation. The arrows indicate the collateral channels through which the abnormal turgescence of the capillaries is effected. *C. O. Weber* has already published a similar diagram.

The infiltration is very speedily followed by the formation of an abscess. The parenchyma which has hitherto served as a supporting framework undergoes total disintegration; the solid hepatised tissue melts into a yellow, creamy pus, in which only a few shreds of the alveolar textures, *sc.* elastic fibres and arterial coats, remain suspended. The affected portion of the parenchyma is thus entirely cut off from the organism—annihilated; its place is taken by an abscess.

§ 477. Let us now consider the various conditions which may result from the combination of the hæmorrhagic congestion on the one hand with the suppurative inflammation on the other. We have, 1st, the case where an artery of considerable size, supplying about a fifth part of a lobe, is plugged by a large embolus. The collateral replenishment of this area is very complete; but the risk of stagnation is also very imminent; hence a condition nearly identical with hæmorrhagic infarction is brought about. The inflammation is limited to the edges of the plugged area; here we find a zone of tissue about a line in width, either infiltrated with pus, or even quite liquefied; the appearances are those of a circumscribed necrosis, with a sequestrating suppuration designed to facilitate the removal of the mortified part. Diametrically opposed to this is, 2nd, the case where a very brittle embolus has been splintered into a number of fragments by impact upon the various forks which it has had to pass; each of these fragments blocking a vessel of relatively narrow calibre. We then find a large number of foci, varying in size from a hemp-seed to a cherry, scattered through the affected lobe; these foci being in a state, either of hepatisation, or of purulent liquefaction. In this case the stagnation of the blood fell short of absolute stasis; it only went as far as an inflammatory hyperæmia might have gone, so as to give the entire process the character of a circumscribed suppurative inflammation without actual necrosis. Between these two extremes lies a very varied series of combinations; thus *e.g.* we not unfrequently meet with small foci, hæmorrhagic throughout, girdled with narrow areolæ of inflammation; again the extent of the inflammation may be utterly out of proportion to the size of the plugged vessel, the hepatisation—which in these cases indeed, is not invariably purulent, but quite as often croupous—extending through one-half or the whole of a lobe, &c.

§ 478. The superficial, subpleural position of the majority of metastatic abscesses is highly characteristic, and has not as yet been adequately explained. We rarely find them in the middle of the lung, towards its root. Hence the invariable implication of the pleura in the inflammatory changes. The usual appearances are those of an inflammation, primarily adhesive, and attended by a copious serous transudation, but soon passing into the purulent form (§ 276). The infection of the serous sac is due to the diffusion of putrid fluid from the abscess or mortified part into the pleural cavity. The continuity of the pleura usually remains intact; nay it often happens, singularly enough, that the patch of pleura immediately over the abscess exhibits no ostensible change; while round about it the membrane is coated with a viscid layer of yellowish-white exudation. It may fairly be assumed that exudation has been checked over the site of the pulmonary lesion, by the pressure of the lobular infiltration having rendered the pleural vessels impervious from the first; while at a later period, the occurrence of gangrene excluded all possibility of inflammation. Perforation of the pleura, either at the centre or at the edge of the deposit, now and then occurs; the sodden and half-melted fibres of the connective tissue separating to allow the pus, the sanies and the air, to enter the pleural sac. It is self-evident that such a catastrophe must infinitely increase the patient's danger. Supposing the pleurisy to have been moderately intense up to that time, the occurrence of perforation at once makes it assume a most malignant type, and renders all hope of recovery futile.

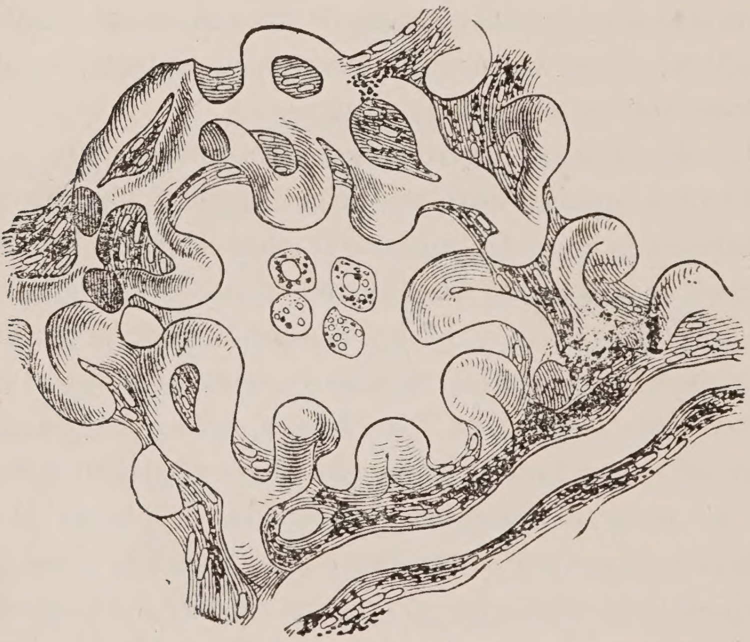
7. DISEASES OF THE LUNGS CONSEQUENT ON HEART-MISCHIEF.

§ 479. Considering the intimate relations which subsist between the heart and the lungs, and their respective functions, we cannot wonder at finding that of all the organs of the body, the lungs are the first to sympathise with diseases of the heart. And it is mainly to impeded circulation through the left heart (insufficiency and contraction of the mitral and aortic valves) that "increase of tension in the lesser circulation" (§ 255), followed by a series of morbid phenomena in the respiratory apparatus, is due.

§ 480.—I. Bronchial catarrh. The larger bronchi are provided with vessels of their own in connexion with the systemic circulation (bronchial arteries and veins); these vessels would be indifferent *per se* to any increase of tension in the pulmonary circulation, were it not for the fact, established by *Rossignol*, that they freely anastomose with the proper pulmonary vessels; this explains how it is that most persons suffering from insufficiency and contraction of the mitral valve are subject to a chronic passive hyperæmia of the bronchial mucous membrane, predisposing it to catarrhal inflammation; hence obstinate and recurrent bronchial catarrh is one of the usual consequences of mitral disease.

§ 481.—II. Brown induration of the lungs. This used formerly to be considered a peculiar form of chronic inflammation. *Rokitanski* tries to make out that it is a hypertrophy of the connective tissue of the lungs, associated with a diffuse, brownish pigmentation, which gives the organ a jaundiced hue. And such an interpretation of the phenomena ought not in any way to surprise us. For the lungs, when taken out of the chest, appear very heavy, bloated, tense and hard, but not infiltrated, or even œdematous; they are crepitant throughout; their colour is a yellowish-brown; and what is most important, microscopical examination of recent sections shows a very decided thickening of the alveolar and infundibular septa, which may be unhesitatingly viewed as the proximate cause of the entire morbid state. But to interpret this thickening as an inflammatory induration, was premature. For although it neither can nor need be denied that the amount of interstitial connective tissue is in some degree increased, yet the chief stress must be laid, not upon this, but upon the state of the capillaries. These are elongated and dilated in a high degree. If we inject a lung, affected with brown induration, with a transparent solution of gelatin (*Buhl*), or if we tie off bits of the lung which happen to be naturally well-injected, and soak them, first in hydrochloric acid and then in spirits of wine (*Colberg*), examining sections of medium thickness from either specimen, we may assure ourselves of the interesting fact, that the well-known capillary twigs which ramify upon the alveolar septa, project much farther than usual into the air-cells, that they are strikingly dilated and often appear even varicose at their points of flexion (fig. 138). The dilatation reaches an average diameter of from ·01 to ·02 mm., while the limits within which the diameter of normal capillaries may vary, are from ·003 to ·007 mm. The bulging of the capillary loops on all sides at once, must of course narrow the alveoli very considerably; hence the little air these lungs contain. To explain how the older view came to be adopted, it is necessary to add, that if the blood be allowed to run out of the capillary loops—as invariably happens when sections are cut from the recent tissue—the capillaries can no longer be distinguished from the remaining constituents of the alveolar wall, and the general aspect is that of simple thickening of the interalveolar septa. The larger interlobular vessels also, particularly the branches of the pulmonary artery, are markedly dilated; here, however, the dilatation of the vessels is undoubtedly associated with a not

Fig. 138.



Brown induration. An alveolus with dilated capillaries; pigment deposited partly in the connective tissue of the septa, partly in the catarrhal cells contained in the interior of the alveolus. $\frac{1}{400}$.

inconsiderable overgrowth of the interlobular connective tissue. I am far indeed from wishing to deny that in this instance, as in the analogous conditions of the liver and kidneys, hyperplastic processes are associated with the dilatation of the vessels. Especially would I direct attention to the constant occurrence of a very marked hypertrophy of the muscular constituents of the pulmonary parenchyma. This sets out from the point where the bronchi open into the infundibula. This point is furnished with a sphincter-like ring of muscular fibres. Starting from this point, a number of muscular fasciculi run downwards in the infundibular walls, forming loops; these unite here and there to form stouter transverse rings which encircle the infundibulum at right angles to its axis. I think it not unlikely that this very considerable increase of contractile power may underlie the well-known immunity of lungs affected with brown induration from such disorders as set out from the retention of catarrhal secretions (catarrhal pneumonia and phthisis).

In consequence of the persistent congestion of the pulmonary parenchyma, minute ruptures occur here and there in the capillary vessels and arterioles. The fate of the extravasated blood is different, according as it is poured out into the alveoli, or retained in the parenchyma. In the former event it is expectorated, imparting a yellowish tinge to the sputa; in the latter, it causes the yellowish-brown pigmentation of the lungs which has been more than once alluded to; this being, together with the increase of density, the most striking naked-eye feature of the disease. On examining the lung more carefully, we notice, in addition to the diffuse staining, brown and yellow dots, both underneath the pleura, and more especially upon the cut surface of the organ, mingled with recent extravasations of a red colour. The brown and yellow dots are heaps of pigment-granules which have obviously been left wherever extravasations have previously occurred. The pigment is partly free, partly enclosed in cells, as in the colliers' and ironworkers' lungs (fig. 138). It is worth mentioning moreover, that the pigment-granules are especially common in such elements as lie free in the interior of the alveoli, elements which have been taken by authors for "detached epithelial cells." It is very unlikely that this "epithelial pigment" should have originated in the alveolus, inasmuch as a period of weeks, at the very least, is required for the conversion of the soluble colouring-matter of the blood into solid pigmentary matter—a much longer interval therefore, than that during which the so-called epithelium-cells abide in the alveolus. The pigment-granules must accordingly have come from the connective tissue of the parenchyma; and since it is not likely that they would have spontaneously taken the direction towards the free surface, we very naturally conclude that they have been carried by the cells in which they are embedded; and this view of course implies that the cells themselves are migratory corpuscles which have made their way to the surface, and not true epithelial elements at all. This view is further corroborated by the smallness of their size, as compared with those elements which fill the alveoli in cases of catarrhal pneumonia. The proper epithelia of the air-cells are quite unaltered, so far as my observations go; we must always be very cautious in assuming a desquamative catarrh of the alveoli, since the epithelial cells of the lungs in adults are among the least irritable elements of the body.

§ 482.—III. HÆMORRHAGIC INFARCTION, AND CIRCUMSCRIBED GANGRENE of the lung. This term denotes the stuffing of the air-cavities of a circumscribed portion of the lung with extravasated blood. If we remember what has just been said concerning hæmorrhagic and gangrenous pneumonia, as well as pulmonary embolism, we can hardly fail to note the high degree of anatomical similarity which must and does subsist between hæmorrhagic infarction and the first stage, more especially of embolic pneumonia. We may go so far as to say that hæmorrhagic infarction is a result of embolism; for we cannot fail to recognise the presence of the anatomical features of infarction, when we find a "hæmorrhagic transudation" (Cf. § 475) due to plugging of a large branch of the pulmonary artery, passing into actual hæmorrhage. Cases of this sort are especially common in heart disease; coagula ("polypi" of the heart) form in the trabecular network of the right auricle or ventricle in consequence of stagnation of the blood in their interior; bits of these coagula are detached, and serve as emboli. Nevertheless these embolic infarctions can be distinguished from such as are due to rupture of a vessel of considerable size; for in the former variety, the transition from the stuffed parenchyma to the normal tissue round it is very gradual, passing through all the stages of hæmorrhagic and simple hyperæmia; while in the non-embolic form, the affected part stands out in sharp contrast to the surrounding tissues as a solid wedge of uniform density and of a deep red colour. Such wedges originate, not in embolism, but in rupture of a vessel of considerable size; they are chiefly found in persons suffering from heart-disease. The increased tension in the pulmonary circulation must be regarded as their predisposing cause. From this point of view, the infarction is merely a gigantic variety of those capillary hæmorrhages with which we became acquainted in brown induration. "Fatty erosion of small and medium-sized branches of the pulmonary artery" may with great likelihood be regarded as in all cases the proximate cause, determining the spot at which rupture of the vessel occurs. Of course this can only be proved by a very minute investigation of the branches of the artery, since it is quite possible that we may fail to detect in the main trunk, any trace of a process which threatens the integrity of the minuter vessels so seriously (Cf. § 220). Finally, a transient fluxion must be assumed in every case to furnish the exciting cause of the lesion—bringing the diminished resisting power of the vessels into collision with the increased demands made upon it.

§ 483. When rupture has once occurred, the blood forces its way into the nearest bronchus with all the violence of the abnormal tension which prevails at the time in the lesser circulation. On reaching the bronchus, some of it is sucked down, filling every part of the corresponding lobule as far as its terminal sacculi; some trickles along the bronchus in the contrary direction; on its way, it comes across other bronchi which branch off from the first; the inspiratory current sucks it into these also. Finally, the dangerous process is brought to a stop by the occurrence of coagulation. The amount of blood which escapes before coagulation sets in is of course proportionate to the calibre of the ruptured vessel; this also determines the size of the wedge-shaped portion of lung which is rendered "apoplectic." The arrest of the hæmorrhage is due to the elastic reaction of the over-distended parenchyma which compresses the bleeding point and checks all further extravasation. This elastic pressure is certainly very characteristic; it is chiefly responsible for the changes which next ensue in the infarction; for, besides its conservative action in compressing the bleeding vessel, it is productive of positive harm by compressing all the vessels in the interior of the affected part equally, thereby arresting the flow of blood through them, and causing the death, the mortification of the part.

§ 484. In contrast to the diffuse variety of gangrene described above (§ 471) we have now to consider a CIRCUMSCRIBED form, as the normal termination of hæmorrhagic infarction. The solid, dusky mass which protrudes equably above the level of the sectional or the external surface, undergoes necrosis at all points at once. Its red colour is changed to a dirty-green, the coagulated blood putrefies and becomes liquid; at the same time the softer constituents of the parenchyma dissolve away, only the elastic fibres and the thicker layers of connective tissue round the vessels and bronchi resisting liquefaction, and forming a shreddy, tinder-like substance which is loosely suspended in the sanies by its connexion with the entrance-point of the vessels and bronchi. These shreds have an exceedingly offensive odour, which becomes apparent to the patient as soon as the clot which plugs the afferent bronchus softens and allows the contents of the gangrenous cavity to mingle with the expectoration. The diagnosis is further confirmed by the detection of elastic fibres in the sputum.

The development of this condition depends chiefly on the behaviour of the tissues immediately surrounding the mortified part. It is obvious that the latter must cause the most intense irritation. A croupous inflammation of those lobules which environ the gangrenous part is accordingly a very usual and generally fatal complication of circumscribed gangrene; so too, pleuritic exudations, consisting of sanious and decomposing pus, are invariably excited by such gangrenous deposits as are in contact with the pleura. Apart from these wider consequences of the local mischief, allusion must also be made to a more limited inflammatory process, which runs its course in the immediate neighbourhood of the mortified tissue, and which, supposing it to be developed in time, exerts a salutary influence, resulting, and that not so very seldom, in the repair of the mortified part; I refer to the sequestrating inflammation and suppuration which occur at the junction of the gangrenous with the healthy tissues, shutting off the one from the other. Thanks to the peculiar mode of origin of the infarction (alluded to above), it coincides most accurately with the boundaries of the lobules. Whatever its form and size, it must necessarily have a layer of interstitial connective tissue at every point of its periphery; and this, as is well known, is far better adapted than the proper parenchyma of the lung, to undergo rapid suppuration, and so to break off all connexion between the infarction and the healthy tissues. The reparative process is completed, after the liquefaction and expulsion of the affected part, by the development of a granulating surface, and a cicatricial contraction of the cavity.

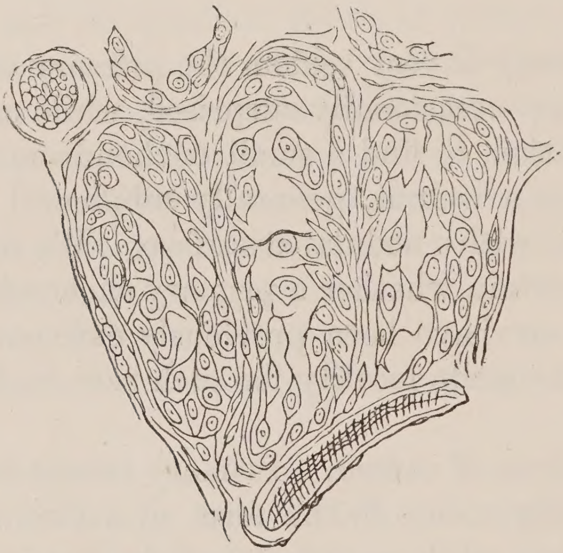
8. Tumours of the Lung.

§ 485. The lung is very seldom the primary seat of morbid growths. We are occasionally surprised, while making a post-mortem examination, to find a small enchondromatous tumour, never larger than a walnut, generally subpleural, consisting of hyaline cartilage, with a nodulated surface. We must, however, be careful to ascertain whether a primary enchondroma may not exist elsewhere, or have been previously extirpated, since the lung is a very favourite locality for such rare enchondromatous metastases.

The same is true of cancer. Primary cancer is very rare in the lung, and only occurs in the form of a circumscribed medullary infiltration, while secondary nodules are less uncommon. Epithelial cancer, when present, is invariably secondary, and always forms small nodules from the size of a millet-seed to that of a pea.

§ 486. As regards the histology of these tumours, it must be laid down as a general proposition, that they are exclusively restricted to the stroma of the lungs. Even though microscopic examination should lead at first sight to the conclusion that a distension of the alveolar cavities is everywhere associated with the swelling of their septa, we must not overlook the circumstance that the former phenomenon is a necessary consequence of the latter. Like miliary tubercles (which, for sufficient reasons, were discussed in § 446), all tumours of the lung, at a certain stage of their development, protrude into the air-cells; they may even completely fill them, but they must not on that account be regarded as analogous to inflammatory exudations, an error into which *Rokitanski* formerly fell. *O. Weber* deserves the credit of having recently directed attention to this point, which is of great histological importance. Unfortunately however, his description of the origin of epithelial cancer can only be accepted as a contribution to the development of morbid growths generally; for the case which he investigated (the specimens are all preserved in the Museum at Bonn), though originally an epithelioma of the tongue, recurred as a simple cancer. The descriptions of epithelioma of the lung furnished by *Virchow* and *Dupuy* are also equally applicable to ordinary cancer—so far, at any rate, as the histological appearances are concerned. Now we must either admit a singular monotony in the textural changes, as they occur in the lungs, or else we must conclude that what variety there is, has not as yet been clearly enough made out. For my own part, I am only acquainted with one set of appearances exhibited by cancerous degeneration in the lung—those already described by the above-named authors. The alveolar network produces a number of nests and rows of cancer-cells, which invade each alveolus from its circumference (fig. 139). In addition, I would only direct attention to the great frequency of inflammatory changes in the parenchyma immediately around the tumour, changes which belong to the category of catarrhal inflammation, and lead to

Fig. 139.



Cancer of the lung. Gradual invasion of the alveoli. Degeneration of the septa. $\frac{1}{300}$.

the distension of the alveoli with a dry, highly-corpusculated infiltration. It is extremely difficult to distinguish these two sets of phenomena from one another in each individual case. And yet it is only in this way, as a rule, that we can arrive at a trustworthy conclusion with regard to the real size of the cancerous nodule. All this shows that the histology of cancer of the lung is still in its infancy; the comparative rarity of the disease being chiefly to blame for our imperfect knowledge.

VII.—MORBID ANATOMY OF THE LIVER.

§ 487. On taking a general view of the various forms of disease to which the liver is liable, we are involuntarily led to remark that the majority of them originate in one particular element of its structure, whether this be the interlobular connective tissue, the hepatic cells, or the vessels. This at once prompts us to classify diseases of the liver according to their textural origin; such a classification being peculiarly fitted for a manual of pathological histology. Nevertheless I prefer, in the case of the liver more especially, to adopt a loose co-ordination of the various morbid states, in preference to any sort of hierarchical classification; for I regard all nosological systems based on anatomical foundations, however plausible they may appear, to be radically misleading from a clinical point of view. Taking the liver as an example, we should have to associate fatty and amyloid degeneration with parenchymatous inflammation under the common head of "Diseases of the Hepatic Cells;" these conditions having really nothing in common with each other. On the other hand, parenchymatous hepatitis would be detached from the other forms of inflammation which start from the connective tissue, *i.e.* conditions naturally related would be violently kept asunder. I will accordingly follow the anatomical method only so far as to begin with a few of those changes which start from the hepatic cells, because they are at once simpler and more distinct; as I proceed however, I will make the diseases succeed each other more in accordance with their clinical relationships.

1. Fatty Infiltration of the Liver-cells.—Fatty Liver.

§ 488. The point of view from which fatty infiltration of the liver-cells, in common with that of other structures, should be regarded, has already been discussed (§ 61, *et seqq.*). We find it associated both with excessive absorption and with deficient oxidation of fatty matter; most commonly indeed, when both causes co-operate, as in well-nourished persons who take little exercise, in nurslings soon after a meal, in patients suffering from tubercular diseases of the lungs, in those labouring under cardiac affections, associated with the peculiar structural alterations induced by venous stasis, in drunkards, combined with an interstitial development of connective tissue (Cirrhosis). In all these cases, the liver is a storehouse for a portion of the fatty constituents of the serum, which have been absorbed from the alimentary canal, but not yet oxidised, owing to the excessive amount in which they are present. That the fatty matters enter the liver-cells from the blood is strikingly shown by the fact that the fatty infiltration invariably begins in the area of distribution of the chief afferent vessel, the portal vein.* In the slighter degrees of fatty liver, we accordingly find only the outer

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* In the course of the following pages we shall often have occasion to recur to these "areas of distribution" of the afferent and efferent vessels of the liver. I take the opportunity of saying a few words on this most important subject.

In my opinion, the structure of the liver may be most clearly and intelligibly explained by starting from the hepatic vein as a centre. Inasmuch as the finest ramifications of this vessel, the intralobular venules, occupy the exact centre, the axis of the structural units which compose the organ, they may be said in some sort to take the place which, in other glands, belongs to the efferent ducts. The hepatic vein with its branches forms a central skeleton of which the remaining elements of the hepatic structure may be regarded as the investment. The space between the larger branches is uniformly and completely filled, or rather permeated, by means of an arrangement unique of its kind; for these larger branches, apart from the gradual narrowing of their calibre, such as we may see in the branches of any tree, also exhibit a *per saltum* narrowing. If we slit up a hepatic vein, and examine its internal surface, we may see all over it a countless number of minute openings which belong either to true intralobular radicles, or at any rate to little venous twigs whose calibre bears no proportion to that of the vein from which they spring.

The *venula centralis* lies therefore in the axis of the ovoid lobule; the capillaries converge towards it radially from every side; the whole arrangement may be compared to that of the bristles in one of those round brushes which are used for cleaning test tubes. The capillary network encloses oblong meshes in which the liver-cells are embedded. The latter in their turn form a network, the "secreting network," which occupies the meshes of the vascular network, and whose own arrangement has only been made portions of the lobules infiltrated; the yellowish lines which indicate the presence of oily matter, seeming to mark out the boundaries of the lobules rather more distinctly than usual. The course of the minuter changes is highly typical. As regards these I will content myself with referring the reader to the descriptions and figures in § 61. Fig. 140 represents a higher degree of fatty infiltration, such as is often met with in the victims of tuberculosis and heart-disease. The portal zone of the lobules is wholly impregnated with oil; the middle zone exhibits the process in its earliest stage, while the centre is still unaffected. To the naked eye, the cut surface of the organ would now pre-

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out quite lately (*Ludwig*, *Hering*). We are now aware that the wonderful "effusion" of the secreting parenchyma into the interstices of a vascular network—the renunciation of an independent structural unity such as we see in the terminal follicles of an acinous gland or in the cœca of a tubular gland—is only an apparent, not a real exception to the general law. Although each single liver-cell is in contact with a capillary on two of its surfaces, it nevertheless has four surfaces left (viewing it as a cube) for contact with adjoining cells; and the finest bile-ducts—in the form of tubular intercellular canals of exquisite tenuity, but still pervious to injection—are so disposed upon these contiguous surfaces as to form a fine network, which everywhere avoids the capillary network, and is always separated from it by the thickness of an entire cell. In sections, we usually find a double row of cells between two adjacent capillaries; between the rows a bile-duct may be traced for a considerable distance. The trabeculæ of the secreting network—*viewed in this light*—correspond to the tubes of any other gland, where a central excretory duct is separated on all sides from the membrana propria and the blood-vessels by a layer of secreting cells. The union of the capillary bile-ducts to form ducts of larger size takes place at the circumference of the lobules, where they run together with branches of the portal vein and hepatic artery.

Returning to the hepatic vein, whose finest ramifications are surrounded on all sides by the hepatic parenchyma proper which has just been described, we must remember that its eight to ten main divisions separate the liver into a corresponding number of lobes; these are not apparent in a healthy human liver, but are manifested in certain abnormal states of the organ, and especially in the "congenitally lobulated" liver. The intervals between the lobes are occupied by the so-called "portal canals." The trunk of this second tree which enters into the formation of the liver lies, as we know, on its under surface (portal fissure), and consists of the united trunks of the hepatic artery, portal vein and hepatic duct. A quantity of lax areolar tissue, which is continuous with the subserous connective tissue of the peritoneum (capsule of Glisson), forms a common bed for all three; and their association is rigidly maintained throughout sent the "nutmeg" aspect. The exquisite plications of the bright-yellow cotyledons in the nutmeg, when seen in section, contrasted with the darker colour of the surrounding parts, correspond in the liver to the yellowish-white tint of the portal zones of the lobules, contrasted with the darker hue of their centres. The comparison is peculiarly apt if we limit our attention, not to a single lobule, but to the ramifications of a single portal canal of small size, which, owing to its branches being everywhere bordered by a selvage of fat, assumes a foliated appearance like that of an oak-leaf—or if the comparison be preferred—like the folded cotyledon of a nutmeg. The term "nutmeg liver" denotes no more than that the periphery of each lobule is lighter than its centre, without in any way deciding whether the phenomenon is due to an abnormal paleness in the former, or an abnormal depth of colour in the latter region. A "nutmeg-liver" of this latter kind is met with in

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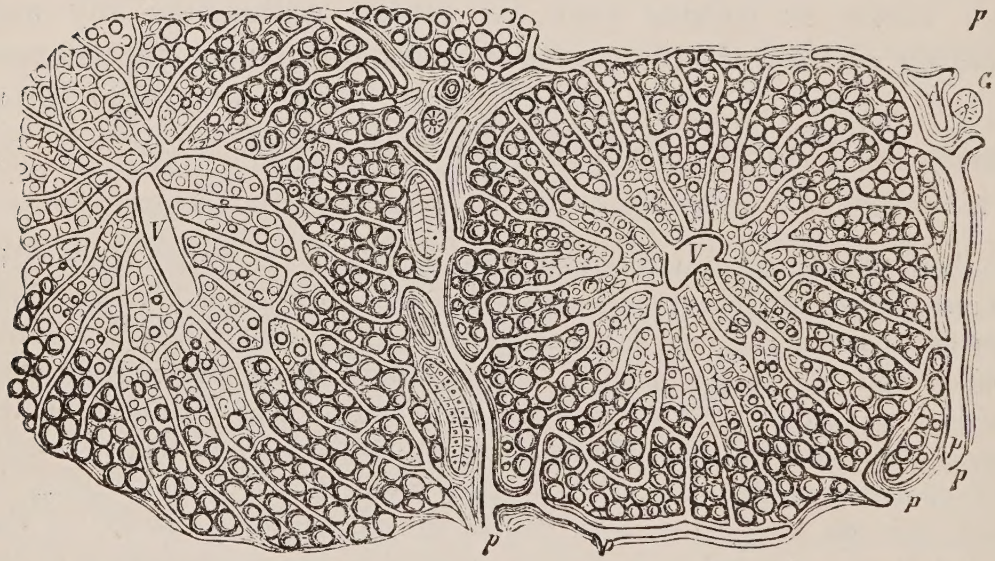
all their subsequent ramifications. In examining a section under the microscope, we can never be long in doubt as to whether a vessel which happens to be in the field is an afferent or an efferent vein. The intralobular vein is always isolated, and separated from the neighbouring vessels by a broad band of hepatic parenchyma. The branches of the hepatic artery and the interlobular veins are either accompanied by a bile-duct of corresponding size, just as they were in the portal fissure, in which case we have to do with one of the larger portal canals; or else we find them separated by a distinct interval at the circumference of the lobule, but with their mutual connexion still shown by the last remnants of their common fibrous sheath, which stretch from one to the other in the form of threads or membranes. It is only at the periphery of the lobules that the three begin to diverge from one another; the finest twigs of the portal vein lying at the junction of three or more lobules, and from hence distributing their terminal branches between every pair of these lobules (fig. 140); the arteries penetrate half way into the interior of the lobule, where they break up into a capillary network. We may thus divide the lobule into three concentric zones; the centre is formed by the part immediately surrounding the intralobular venule; the area of distribution of the portal vein forms the circumference, while the hepatic artery is distributed to an intermediate zone. Of course we must not suppose that these respective tracts are sharply marked off from one another; on the contrary, the community of the capillary network renders any such strict limitation impossible; yet a knowledge of the more intimate relation of these three zones to their respective vessels is of importance in guiding us to a right comprehension of a long series of morbid states.

cases of heart-disease, where a dilatation of the hepatic radicles (to be described hereafter), together with a pigmentation, deepen the tint of the central portion of each lobule. Should the liver be fatty in addition, the contrast will of course be all the more violent.

§ 489. Should the fatty infiltration proceed far enough to cause every liver-cell without exception to contain its drop of oil, the boundaries of the lobules are effaced, and the peripheral may cease to be distinguishable from the central parts. The organ presents a uniform yellowish-white or yellowish-brown colour; its consistency is soft and doughy; the finger leaves permanent marks on it; its size and weight are doubled, while its specific gravity is lowered; its edge is rounded, especially below, where it extends downwards into the umbilical region (fig. 150, vi.). All these characters of the fatty liver flow naturally from the quality and quantity of the infiltrated matter; so too, the excessive bloodlessness which is constantly associated with the other changes. We must, however, be on our guard against supposing that the anæmia which we find after death is equally great during life. Pressure and reaction here balance one another. The distension of the liver-cells with oil must undoubtedly exert abnormal pressure, which, as regards the

Fig. 140.



Fatty liver. Infiltration of medium intensity. Semi-diagrammatic. *VV*. Intralobular veins; *pp*. Interlobular branches of the portal vein; *AA*. Arteries; *G*. Bile-ducts.

vessels in the interior of the liver, must be quite equivalent to compression from without. This pressure, however, is elastic, and is overcome to some extent by the opposing pressure of the blood; we may assure ourselves of this by forcing injection into the portal vein, which admits it without the application of any extraordinary force. It is only when the *vis a tergo* of the heart sinks to zero that the elastic reaction of the distended cells makes itself fully felt, and drives what blood may still exist in the parenchyma back into the greater vessels.

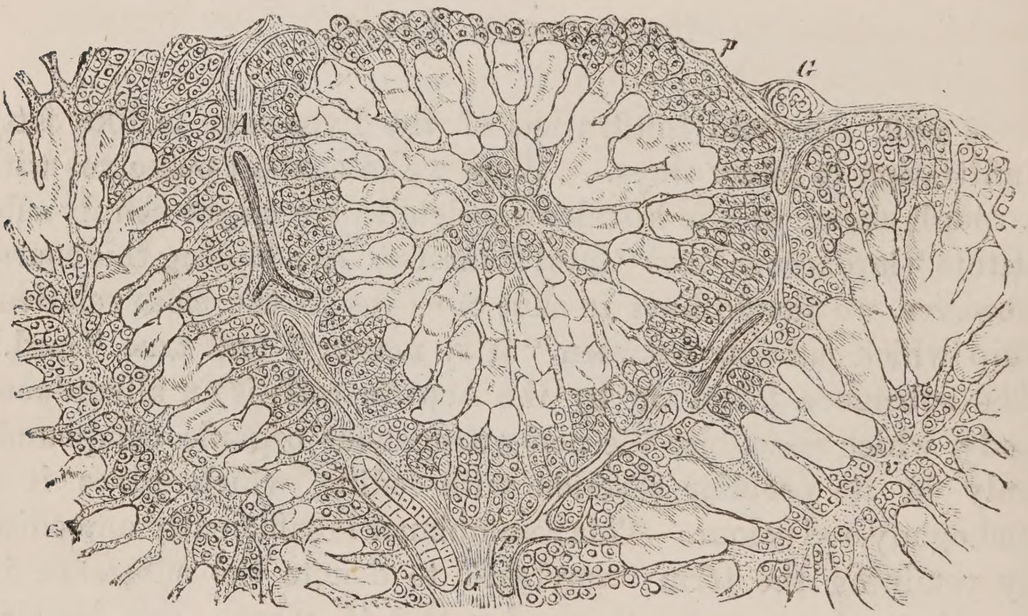
2. AMYLOID INFILTRATION OF THE LIVER-CELLS.—LARDACEOUS LIVER.

§ 490. Amyloid infiltration of the liver-cells is like fatty infiltration in many ways. Were we to content ourselves with a rough sketch of the histological details, we might simply substitute "lardaceous" for "fatty" matter. In adopting this course however, we should have to shut our eyes to the close relationship which subsists between "fatty matter" and true "lard." The substance taken up by the hepatic cells is an albuminous body, which resembles the non-nitrogenous organic compounds only in its peculiar reaction with iodine, which gives it a mahogany-red colour. This resemblance is sufficiently embodied by retaining the term "amyloid" to denote the substance in question. I may refer the reader to § 46, where, side by side with the question as to the origin and chemical position of the "amyloid" material, the histology of amyloid infiltration of the liver-cells is discussed. We then learned how the individual elements increased in size by taking up the amyloid substance, how their sharp outlines were blurred, how their contents assumed a dull and homogeneous lustre, how their nuclei disappeared, and how they were finally converted into glassy flakes or spherules.

If we trace the progress of the changes in a single lobule, we cannot fail to observe that the amyloid matter is first deposited in that region which I have already described as the area of distribution of the hepatic artery. The annexed figure (fig. 141), which represents a moderate degree of amyloid infiltration of the liver, shows clearly how the glassy swelling of the secreting network has spared (at any rate for the time) the peripheral zone, beginning about midway between the circumference of the lobule and its centre, and extending inwards from this point to a variable distance from the hepatic radicle. This fact indicates a certain analogy with the amyloid degeneration of other organs, where the infiltration begins in the smaller arteries themselves, and extends from thence to the capillaries. The small arteries are also affected in the liver, but the morbid changes extend, not to the capillary walls, but to those liver-cells which immediately environ the arterial capillaries.

As the disease goes on, the area of the hepatic vein is first invaded; then, and not before, does the infiltration spread to the cells of the portal zone. When this stage too is at an end, each individual liver-cell, and consequently the organ as a whole, contains twice or three times as much solid albuminous matter as it normally does; each individual liver-cell, and consequently the organ as a whole, is twice or three times as large and as heavy as it ought to be; each liver-cell, and therefore the entire organ, is of a pale-grey colour, translucent and waxy. The comparatively sharp edges of the normal liver are rounded off just as in

FIG. 141.



Amyloid Liver. *A.* Interlobular artery with amyloid walls. *GG.* Bile-ducts. *pp.* Portal veins. *VV.* Intralobular veins. The liver-cells in the middle zone of each lobule are infiltrated with amyloid matter. $\frac{1}{300}$.

the fatty liver; the diagram (fig. 150, vii.) gives some idea of the colossal dimensions which the organ may attain.

The small amount of blood in the amyloid, as in the fatty liver, deserves especial notice. The anæmia is of course directly proportionate to the enlargement of the liver-cells. The greater the infiltration, the less blood will pass through the organ in a given time, and the more will the hepatic functions be impaired —and this quite apart from any direct injury to the secreting cells. The bile is very thin and scanty; it probably suffices however, for the needs of an organism whose nutrition is already much enfeebled. The capillaries indeed remain pervious to the last. An amyloid liver, in whatever stage, may be perfectly injected; and it is in injected specimens that we are able to demonstrate the localisation of the disease in the hepatic cells.

§ 491. Besides the diffuse infiltration of the liver with lardaceous matter, we are also acquainted with a variety in which the deposits are circumscribed; I have only seen one example of this condition, associated with red atrophy (*see* below). The liver as a whole showed but slight traces of amyloid degeneration; but the atrophy resulting from passive congestion had already given it a lobed appearance. Here and there, in the interior of the lobes, solid nodules as big as walnuts were embedded; each nodule being softened at its centre. Minute investigation showed a high degree of amyloid infiltration, with pus in the centre of each nodule. The suppuration was clearly secondary; for the isolated lobules, infiltrated with waxy matter and, owing to the great chemical indifference of this deposit, but little changed, could be seen floating in the scanty pus derived from the connective tissue of the portal canals.

Amyloid and fatty infiltration are not seldom found associated; the latter usually presenting the characters of an occasional and accidental complication.

3. CONDITIONS OF HYPERTROPHY.

§ 492. Only those conditions can be regarded as truly hypertrophic, in which an obvious increase in the bulk of the entire liver is brought about by a uniform enlargement or multiplication of all its component textures. Accordingly, we judge a liver to be hypertrophied when we find a decided and striking enlargement of its constituent lobules ; this enlargement usually contrasts with the healthy state, inasmuch as in the majority of instances, it is demonstrably due to infiltration or to the development of some morbid growth. An attempt has been made to distinguish between hypertrophic and hyperplastic enlargement of the liver, using the former term to denote an increase in the *size* of the hepatic cells, while the latter is confined to an increase in their *number*. The utility of such a distinction seems to me very problematical, since considerable variations in the size of the cells, and appearances indicative of corpuscular proliferation, may often be observed in perfectly healthy livers. We have only one fixed point to guide us in our decision, *sc.* the fact that a development of new lobules does not occur under all conditions, and that every hypertrophy must at first present itself as a simple increase in their size. A just estimate of the comparative size of the lobules is made easier by the restriction of the hypertrophy (at any rate in extreme cases) to circumscribed portions of the organ. As a general rule, the hypertrophy is vicarious, compensating for losses due to atrophy elsewhere ; so that we are often able to compare lobules which are either too large or too small with others of normal size. Under this head comes the compensatory hypertrophy of single lobes associated with the formation of cicatrices, with atrophy due to pressure in other parts of the liver ; it is by no means rare. Those cases of moderate and uniform hypertrophy which are due to leukhæmia or diabetes mellitus on the one hand, to prolonged residence in hot climates on the other, are far more difficult of recognition. In these cases, we are very liable to mistake a spurious for a true hypertrophy. The risk of error is greatest in the leukhæmic form of enlargement, which depends, in the majority of cases, on an infiltration of the organ with colourless blood-corpuscles ; I would advocate caution in cases of diabetes also. In the latter disease we are usually able to differentiate the three vascular zones of each lobule. The secreting network of the portal area appears swollen rather than positively enlarged ; its nuclei assume a wine-red colour on the addition of iodine, which points to the presence of glycogenic matter in their interior ; the outlines of the cells are indistinct, owing *perhaps* to an increase in their bulk. The middle zone, the area of the hepatic artery, is fatty; the central part seems almost normal; its secreting cells only exhibiting casual traces of the change which we noticed in the peripheral zone.

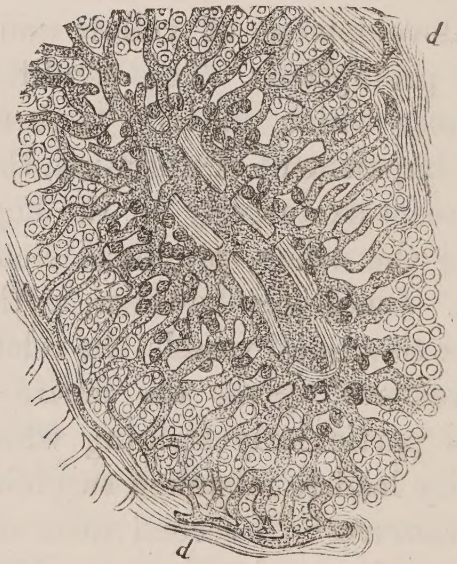
4. CONDITIONS OF ATROPHY.

§ 493. SIMPLE ATROPHY. In half-starved individuals, in the subjects of œsophageal stricture, in those lunatics who reject their food, in marasmus from whatever cause, we find the liver remarkably small and brown; its capsule is lax and wrinkled; and this uniform contraction of the organ seems to depend on a shrinking of all the liver-cells to a third of their normal size, together with a development of yellow and brown pigment-granules in their protoplasm. The conditions are obviously antagonistic to those which underlie hypertrophy; we notice, however, that the impairment of nutrition, the diminished functional excitation, react exclusively on the hepatic cells, making them waste, while the other structural elements remain provisionally normal. Inasmuch, however, as this residue consists solely of connective tissue and vessels, the relative preponderance of this "fibrous texture" gives the entire organ a leathery toughness; this is particularly striking when the liver is cut into, and may easily lead to mistaken suspicions of cirrhosis.

§ 494. RED ATROPHY. A second form of general atrophy is caused by those cardiac and pulmonary disorders which give rise to passive congestion of the systemic veins. The hepatic veins which open into the inferior cava barely an inch from its termination in the right auricle, must naturally be exposed in the very first degree to the effects of the augmented blood-pressure. A chronic, intense venous hyperæmia is accordingly the immediate cause of all the structural changes. One half, at least, of the space occupied by the liver is normally taken up by the blood. We can hardly be surprised therefore, to find that even a moderate degree of congestion should cause a very notable enlargement of the entire organ. Should the capillaries be distended to only twice their normal calibre, this must at once increase the bulk of the liver by nearly a half. The demand for space on the part of the blood is in great measure satisfied by the enlargement of the organ as a whole; the remainder being gradually met at the expense of the parenchyma between the vessels. The secreting tissue wastes, and the liver-cells, as they disappear, are replaced by dilated blood-vessels; hence *Virchow* has given the disease the very apt name of "red" atrophy.

§ 495. As might have been expected, the obsolescence of the secreting cells does not proceed uniformly in all parts of the lobule; it begins where the abnormal pressure is greatest, in the area of the intralobular vein. What strikes us most on looking at a section made through a duly injected and hardened lobule (fig. 142) is the dilatation of its central vein. Moreover the vein is not simply dilated; it is also thickened, often very markedly so. It communicates at various points with the surrounding capillaries by intermediate branches of considerable size, which penetrate its wall either in a straight line, or with a short spiral twist. To some distance from its outer surface, the spaces destined for the reception of the liver-cells are seen to be vacant. A few isolated elements of very small size, full of yellowish-brown or black pigment-granules, indicate the former site of the secreting network. These, however, are seldom in immediate contact with the vessels; there is a clear interval

FIG. 142.



Red Atrophy. *a.* Central vein of a lobule; *d.* interlobular connective tissue, increased in amount. For other references see text. $\frac{1}{200}$.

between, which I agree with *Biesiadecki* in recognising as the interior of a lymphatic vessel or perivascular space. Accordingly we may regard the liver-cells as having succumbed to the stasis of blood and lymph in exactly the same way as they would have done to external pressure; and this condition extends to a variable distance from the centre of the lobule. The change usually attains its maximum along the course of the principal veins. We may even find on the surface of the liver after its removal from the body, from three to five fissures running forward from its posterior border, growing shallower by degrees, and breaking up into a number of smaller fissures; just as the bed of a river breaks up into a number of smaller tributaries as we approach its source. These clefts correspond in depth to the number of liver-cells which have been destroyed. We find thousands of lobules, none of which contain a single cell; some are obsolete, others again may be perfectly injected. Together with them we find lobules which are only half destroyed, others which are still relatively whole. We must be very careful not to confound such a condition as this, with those forms of inflammation which lead to a growth of connective tissue in the portal canals; the subsequent contraction of this tissue giving rise to inequalities of the hepatic surface precisely similar to those just described, the organ presenting a lobed and granular appearance (*see* Cirrhosis). It behoves us to be especially on our guard, as red atrophy is not seldom found in conjunction with a proliferation of connective tissue in the portal canals. We will not attempt any dogmatic explanation of this fact. We might assume that the abundance of nutrient matter in the congested liver served as a predisposing cause of morbid growth; with equal probability however, we might say that a primary cirrhosis had become complicated by atrophy due to passive congestion.

§ 496. The combination of red atrophy with fatty liver has already been referred to (§ 488). Distension of the peripheral layer of secreting cells with oil, recession with dark-red or brown staining of the central portion of each lobule; such a combination as this must obviously give rise to the most characteristic form of "nutmeg" liver. We will call it the "pigmented nutmeg liver."

§ 497. YELLOW ATROPHY. (Acute yellow softening.) The aggregate of highly characteristic symptoms which constitutes "malignant jaundice" (*icterus gravis*), corresponds to an equally characteristic structural change in the liver, which gets its name of "yellow atrophy" from two of its principal features. All observers are agreed that within a period of from three to four days or even less, the liver shrinks from its normal dimensions to an extraordinarily small size; (the contraction of the area of hepatic dulness may be traced by percussion during life). After death, the liver is found of a sulphur-yellow colour and very anæmic; its surface is smooth, its texture so homogeneous on section that the individual lobules can no longer be distinguished with the naked eye. This last statement, however, is only true conditionally. *Frerichs* and *R. Demme* have often detected remnants of hepatic parenchyma but little altered, embedded in the homogeneous mass; they describe groups of lobules, of various sizes, which retained their normal structure so completely, especially at their edges, as to allow the individual liver-cells and blood-vessels to be recognised. Wherever the liver-tissue seems homogeneous, these structures are very imperfectly if at all distinguishable. A granular mass, abundantly mingled with oil-globules of all sizes, and here and there with pigment-granules or blood-corpuscles; blood-vessels and connective tissue as if sodden; crystals of leucin and tyrosin; this is all that we can see under the microscope. The term "softening" (biliary liquefaction—after *Henoch* and *von Dusch*), which some authors have applied to this condition, is grounded upon these appearances; as regards the general aspect of the organ, the term is misleading; for the liver as a whole is rather hard and leathery than softened.

§ 498. The process which underlies yellow atrophy of the liver is still shrouded in darkness. We have undoubtedly to do with a dissolution of the hepatic parenchyma, and especially of the secreting cells. Observers are nearly unanimous in attributing the dissolution to FATTY DEGENERATION. But from this point, opinions begin to diverge. Some recent inquirers (*Ph. Munk*, *Leyden*, &c.) are inclined to assimilate this process of fatty degeneration to the changes which occur in phosphorus-poisoning; indeed *Munk* suggests that all cases of acute yellow atrophy may really be due to phosphorus. The chief phenomenon in the disorganisation caused by phosphorus, is the presence of oil-globules in the liver-cells; it is quite possible however that this is preceded by a parenchymatous swelling. The latter phenomenon, according to another set of observers (*Frerichs, Demme*) is the essential feature in yellow atrophy. They regard this disorder as resulting from an acute inflammation of the parenchyma, which they believe to be principally seated in the peripheral parts of the lobule, and capable of being demonstrated in the above-described remnants of hepatic tissue (§ 497). They hold that the swelling of the peripheral zone of cells causes obstruction of the minute bile-ducts which issue from the lobule, followed by retention of bile in its interior; the reabsorption of this bile into the blood giving rise to the jaundice. This theory is accordingly meant to take in the singular fact, that while the larger bile-ducts are always either empty or else filled with colourless mucus, jaundice is invariably present. A third view (*Henoch, von Dusch*) makes the retention of bile in the liver the starting-point of the disease. They believe that the hepatic cells are dissolved by the retained bile, and that the atrophy is therefore a "biliary liquefaction" of the liver. We know, however, that liver-cells may be kept in bile for days together without being dissolved. I think we may spare ourselves the trouble of trying to explain malignant jaundice on the hypothesis that it is due to reabsorption of bile. Everything seems rather to point to its being a form of acute blood-poisoning, in the course of which numbers of red blood-corpuscles become dissolved, or at least give up their colouring matter; this, after being set free, undergoing conversion into bile-pigment without the aid of the liver. The morbid change in the blood would thus be the main element in the disease; it manifests itself likewise by several hæmorrhages, partly parenchymatous (skin, mesentery), partly superficial (nose, bowels). Whether the disturbances in the central nervous system are due immediately to the poison, or result from the altered composition of the blood, there is no decisive evidence to show. *Frerichs* thought that the leucin and tyrosin resulting from the disintegration of the liver-cells mingled with the blood, and caused the nervous symptoms; but it has been shown by direct experiment that these substances may be introduced into the circulation in considerable quantities without producing coma, delirium, cramps, &c. It is doubtful moreover whether the disorganisation of the liver is due to the direct or indirect action of the poison. We may either ascribe the destruction of the liver-cells to the immediate operation of the poison (as in phosphorus-poisoning), or we may assume that the blood, after undergoing changes in its composition, causes the disintegration of the cells. I incline to the former view myself, referring all he phenomena of the disease to the immediate chemical effects of the hitherto undiscovered poison.

It has been established by a series of trustworthy observations (*Waldeyer*, *Klebs*), that yellow atrophy of the hepatic parenchyma may run a more lingering course, and pass into a state which has been termed by *Klebs* "red atrophy." Such livers exhibit patches of varying size in a state of yellow atrophy, separated by depressed bands of liver-tissue of a pale-red hue; the latter are found under the microscope to consist of a lax and flabby connective tissue which contains oil-globules and granules of bile-pigment in narrow lacunar crevices, and besides these, cells resembling the epithelia of the biliary ducts arranged in regularly branching lines and tubes which seem to end cœcally. *Waldeyer* is inclined to regard the latter as evidence of a reparatory proliferation of epithelium, starting from the bile-ducts, and destined to replace the lost trabeculæ of hepatic cells; *Klebs* however, repudiates this view, regarding them simply as altered remnants of what once were secreting trabeculæ.

§ 499. Circumscribed atrophy of the hepatic parenchyma, beginning with a gradual shrinking and absorption of the liver-cells and obliteration of the residual framework of blood-vessels, is found wherever the liver is subject to mechanical compression.

The chief instance of this is "atrophy from tight-lacing." Owing to the compression of the lower aperture of the thorax by the stays, the liver is first of all squeezed together from the sides; it is thrown into a series of shallow folds which traverse the right lobe from behind forwards. At the same time, the edge of the thorax is pressed against its surface. The lobules at this point become atrophied; their place is taken by fibroid tissue, which appears on superficial examination like a thickening of the capsule intruding into the parenchyma. The capsule may, however, be really thickened as well. A furrow is thus produced, which grows steadily deeper and cuts off the anterior part of the right and left lobes; ultimately indeed, the connexion of these lobes with their margins may be purely ligamentous. The part thus "laced off" becomes rounded and nodular; all the channels which are destined to carry away its blood and bile, are compressed at some point or other, and undergo proportionate dilatation in consequence. Even with the naked eye we can see the turgid, varicose veins, as well as the bile-ducts, which are distended, not with bile, but with the clear mucous secretion of their lining membrane. The abnormal mobility of the free border of the right lobe may sometimes result in its being folded over and jammed under the edge of the ribs. Inasmuch as the gall-bladder is attached to it, the dislocation of the cystic and common ducts may give rise to jaundice from obstruction of the latter (*Virchow*).

§ 500. Partial atrophy of the liver may also be caused by the pressure of exudations encysted between the liver and the diaphragm, or collected in the pleural or pericardial sacs. Similar effects may follow the pressure of abdominal tumours. I have recently had an opportunity of observing a highly remarkable case of this kind. The patient was a ricketty puerpera. The pregnant uterus had squeezed the anterior half of the liver against the ribs so forcibly, that side by side with an old fissure due to tight-lacing, there were many atrophic patches of more recent date. These were depressed below the surface, reddish-brown, and very sharply marked off from the healthy parenchyma round them; the lines of demarcation being arcuate with their concavities directed outwards, so that the patches had a stellate form; they varied in size from one millimetre in diameter to a superficial area of several square inches. The microscope showed a nearly total absence of hepatic cells, while the vascular network remained pervious to injection throughout. The case was undoubtedly one of subacute atrophy, since the temporary enlargement of the uterus can only have interfered with the liver during a short time. It is worthy of note that in such cases the liver-cells are the first to suffer, while the vessels continue, for a time at least, unaffected. I am inclined to believe that a complete restoration of the atrophied parts is possible. This would necessitate the renewed occupation of the interstices between the vessels by secreting elements; these may possibly be developed from the few hepatic cells which still survive, or from the corpuscular elements of the connective tissue.

5. INFLAMMATION.

§ 501. PARENCHYMATOUS INFLAMMATION. When we find a liver moderately enlarged in all its dimensions, of a yellowish-grey colour, anæmic, offering a peculiar inelastic and doughy resistance to the finger; smooth on its surface, remarkably dry on section—not unlike smoked meat; when we meet with all these characters, we are justified in referring them to a change in the hepatic cells, termed by *Virchow* "cloudy swelling," and recognised by him as the essential basis of parenchymatous inflammation. It denotes an enlargement of the cells due to the presence of a number of dark (albuminous) granules in their protoplasm. Inasmuch as the protoplasm of the normal liver-cells also contains a number of granules, it is clearly a difficult matter to decide from the appearance of a single element whether the accumulation of granules is within or beyond the normal limits. In extreme cases indeed, the number of granules is so excessive as entirely to conceal the nuclei; but such cases are rare. The increase in size too, is not a reliable criterion when applied to a single cell. The examination of fine sections yields far better results. The first point which strikes us in these is a marked enlargement of the lobules, with an increased distinctness of their outlines. I believe that the latter phenomenon is due to an intense serous œdema of the interlobular connective tissue. The secreting network is somewhat thickened; but we are much more struck by a certain disturbance in its structural relations. In place of the almost pedantically regular arrangement of the individual elements, we find them loosely connected, in a state of disorder hard to describe; the chief point is that the cells are often separated by little intervals; many of them have slipped out of the ranks, so that it becomes incorrect to speak of the "trabeculæ" of the secreting network. It may be that the œdema of the portal canals extends into the interior of the lobules also; it may be that the swollen condition of the cells helps to loosen their mutual connexion by rounding off their angles. Another point struck me as worthy of notice—a point of great importance for the interpretation of the suppurative inflammation which we shall consider next; this is, that the connective-tissue corpuscles in the portal canals, as well as the capillary nuclei, are in a state of formative irritation. Many of the capillaries are coated with long rows or irregular groups of nuclei; similar groups occur in the portal canals, but above all, in the interior of single lobules. The latter are so large as to remind the observer of miliary abscesses.

§ 502. Diffuse parenchymatous hepatitis in its mildest form, is met with in very many blood-diseases; *e.g.* in typhus, in the acute exanthemata (especially variola), in poisoning by various chemical, septic, and animal agents, in puerperal fever, &c. It is nearly certain that in all such cases, complete restoration to the normal state is within the bounds of possibility. For notwithstanding that the attention of observers has been directed for whole decades to this point, no one has ever succeeded in proving that acute parenchymatous inflammation is capable of any other issue. We have already seen, indeed, that some authors regard acute yellow atrophy as an issue of parenchymatous hepatitis; and I myself am inclined to think that idiopathic abscess of the liver may be the final result of a diffuse parenchymatous inflammation. In either case however, there is not evidence enough to decide the question..

§ 503. SUPPURATIVE INFLAMMATION.—ABSCESS OF THE LIVER. We distinguish between idiopathic abscess of the liver, and the deuteropathic or metastatic form. The latter is a result of thrombosis or embolism. The abscesses arise whenever inflammatory and suppurative changes in any part of the organism —particularly within the area of the portal vein—cause coagulation of blood within the vessels. The thrombi may extend from the area drained by the portal capillaries directly into the main trunk and branches of the portal vein (*Pylephlebitis* in the limited sense of the term); in the majority of these cases however, as in all those where the primary mischief is not situated in the portal area, the secondary affection of the liver is due to the intervention of embolism. Among the earliest results of morbid anatomy was the empirical observation that abscesses not unfrequently formed in the liver after injuries to the head. In these and similar cases we ought always to make sure that the liver has not been wounded by a rib fractured during the same accident, or damaged by succussion. Apart from such accidents, however, there remains a sum-total of metastatic processes which may be grouped under three heads:—1st, hepatic abscesses secondary to mischief in the portal area; 2nd, abscesses secondary to disease at any point in the pulmonary or systemic circulation (associated in the latter case with embolic deposits in the lungs). In these latter cases we have grounds for assuming that coagula formed in the pulmonary veins make their way through the left heart into the hepatic artery; 3rd, hepatic abscesses secondary to disease in the domain of the systemic circulation, without the simultaneous occurrence of abscesses in the lungs. This series can only be explained by supposing either that the pulmonary capillaries and the anastomoses between the pulmonary artery and veins are pervious to emboli of small size, or that the examination has not been conducted with sufficient care. Closer investigation usually discovers that apart from the principal wounds, abscesses, &c., which absorb all our attention, there exist some less extensive lesions causing thrombosis in regions from which the portal vein can derive an embolus (*e.g.* at the neck of the bladder, in the hæmorrhoidal plexus, &c.).

§ 504. The anatomy of hepatitis leading to abscess is always the same in its coarser features. The finer details, however, the interconnexion of the individual factors of the process, are modified to some extent in accordance with its mode of origin, as will be seen hereafter. By the coarser features, I understand the development of pus in the portal canals, the growth of the abscesses, the formation of pyogenic membranes, &c. The reason why the suppuration always sets out from the portal canals is to be sought in the greater abundance of connective tissue in their interior. These two facts used formerly to be connected by making the pus-cells actually originate by proliferation of the connective-tissue corpuscles. This view, however, has lost ground since the publication of *Cohnheim's* researches (*see* § 89). For though it must always have seemed rather odd to every conscientious histologist, that in the usual picture of connective-tissue proliferation (fig. 106) the actual *division* of the elements was very seldom to be seen, the theory resting merely upon the presence of large and small chains of cells at a point where only a single connective-tissue corpuscle might fairly have been expected to lie; nevertheless *v. Recklinghausen's* discoveries concerning the "migration of connective-tissue corpuscles" were the first which compelled us to modify our views. The young cells which occupy the lacunar interstices of the connective tissue in irritations of a local character, had to be regarded as for the most part "immigrants." Still, they were the same corpuscular elements, only derived from the neighbouring connective tissue instead of originating on the spot. Even now, we cannot regard the connective tissue as wholly barren, since an experiment of *v. Recklinghausen's* has proved that a moderate amount of corpuscular proliferation may take place under suitable conditions even in portions of the cornea which have been excised. Still, the connective tissue as a source of young cells has fallen very much into the background since we have learned that the colourless corpuscles may emigrate from the blood-vessels and so give rise to all sorts of plastic infiltrations. These considerations recur to our minds whenever we meet with suppuration, and indeed with heterologous formations generally. We have to remodel our conceptions in accordance with them, and while continuing to speak of "corpuscular infiltration of the connective tissue," we must bear in mind that the term "infiltration" is used more strictly than before, to denote impregnation with the constituents of the blood. Now as the connective tissue furnishes an investment for the vascular system, intervening between the blood and the parenchyma, we can plainly see how it is that the connective tissue is so favourite a seat of morbid formations.

Returning to our proper theme, abscess of the liver, we may explain the invariable commencement of the suppuration in the portal canals by the fact that these canals contain more vacant space, susceptible of distension, than exists in the interior of the lobules. In addition to this cause—at any rate when the abscesses are due to thrombosis and embolism—we have the circumstance, that the immediate cause of the mischief first enters the portal canals. From this point however, the textural changes begin to diverge.

§ 505. If the case be one of THROMBOSIS of the portal vein, we can trace the disintegrating blood-clots along some branches of the vessel almost as far as the point where the smaller interlobular veins are given off. The walls of the vein everywhere exhibit those appearances which I have elsewhere described as characteristic of acute phlebitis (§ 212). The capsule of Glisson is also extensively altered, and an abscess of some size is not unfrequently met with immediately round the trunk of the portal tree. The walls of the interlobular veins are no longer distinguishable from their lumina. For they are so completely impregnated with colourless corpuscles that they blend with the contents of the vessel, which also consist entirely of colourless cells.* These elongated, cylindrical, sometimes branching bodies, which may very well be compared to the core of a boil, lie bathed in liquid pus, in a cavity formed between the vessel and its fibrous sheath. The perivascular sheath itself is so abundantly infiltrated with leucocytes that it forms a cushion-like layer about a quarter of a line in thickness, which appears of an intense white colour to the naked eye. This layer is everywhere intercalated between the portal vessels and the hepatic parenchyma, and as lucky sections may bring considerable tracts of the former into view at once, the thrombotic abscess in a certain stage of its development may resemble a twig with its leaves. Each leaflet corresponds in size, more or less closely, to a normal lobule; but the two must never be confounded; for the leaflet is really made up of a degenerated interlobular vessel as its mid-rib, and the infiltrated perivascular sheath, seen in section, as its blade. The latter must also be regarded as the first rudiment of a pyogenic membrane. Its cells are derived, not from the interlobular vessel, but from the surrounding parenchyma. Hence it is organically united with the latter structure, and injected specimens show that it is only its inner surface, that turned towards the vein, which breaks up into or secretes pus, while its parenchymatous side is made up of vascularised embryonic tissue. The parenchyma is thus protected from suppurative disorganisation; I have never succeeded in detecting any extension to the lobule itself, or any thrombosis of the hepatic veins; but the parenchyma suffers all the more from the mechanical effects of the enormous distension of the interlobular spaces. In sections which traverse several adjacent portal canals at right angles to their axes, we may see how the intervening lobules are first altered in structure, and finally destroyed by the pressure to which they are subjected. The trabeculæ of the secreting network which originally radiate, like the blood-vessels, from the central vein, are compressed in the direction of their length; the spheroidal surface of the dilated portal canal governing the arrangement of the rows of cells. These come to form concentric zones round the portal canal, the number of zones being proportionate to its calibre. It soon becomes difficult to distinguish the site of the central vein; and inasmuch as this point is the centre of the former structural grouping, we may regard its disappearance as a proof that the old structure is obsolete. At a later period the existence of the cells themselves is jeopardised. For the more completely they are grouped in the concentric zones above alluded to, and the more the centrifugal pressure tends to stretch and burst these zones, the more also do the cells deviate from their original cuboidal form; they become narrower, then fusiform or ribbon-shaped, and finally so slender as only to deserve the name of fibres. I have never succeeded in making out that they take any part in the proliferation by undergoing fission and endogenous multiplication. Here and there indeed, we may come across a cell with several nuclei; but one cell goes for very little. The majority obviously waste away and perish, and when the lobule is finally obliterated, the layers of embryonic tissue which surround the adjacent portal canals come into contact with one another, and coalesce to form a new structural unit. This new unit is nearly of the same size and shape as a normal lobule; but it is not identical with that anatomical unit which I formerly warned the reader not to mistake for a lobule; it really does *replace* a lobule; but neither is it a "lobule which has suppurated," however much the aspect of these white granules, freely suspended in the pus and limiting the abscess-cavity on all sides, may tempt us to think so. It is the greatest mystification which pathological histology can offer to the naked eye; for it leads the observer to conclude involuntarily, that in abscess of the liver, the lobules are simply macerated in the pus which fills the portal canals; whereas the supposed lobules are really nothing more than shreds of the pyogenic membrane, the hepatic parenchyma having disappeared long before.

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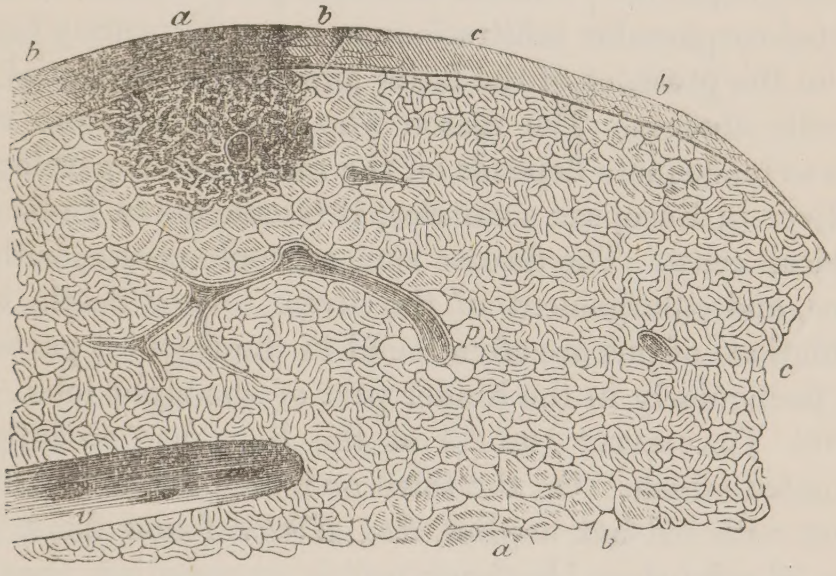
* Cf. *Buhl's* recent investigations, quoted in § 530, concerning the way in which the cells contained in the vessel originate.

As the abscess gets larger, one pseudo-lobule after another melts away, while new ones are continually being formed and isolated at the periphery. It is only the main branches of the hepatic vein which still persist for a long time as points of attachment for considerable numbers of pyogenic pseudo-lobules; and this contributes not a little to give the cavity of the abscess a ragged and irregular appearance.

§ 506. THE EMBOLIC ABSCESS differs from the thrombotic variety only in its earliest stages. It begins with a circumscribed congestion, limited to that portion of the liver which is supplied by the plugged vessel, whether this be an artery or a branch of the portal vein. The congestion is most intense; the capillaries are distended to their utmost; it usually terminates in complete stasis. The condition in question is strictly analogous to that which results from embolism in the lungs; it differs only in the absence of the hæmorrhagic extravasation which usually occurs in the lung. The liver is in general less liable to parenchymatous hæmorrhages than any other organ, notwithstanding, perhaps indeed because of its great vascularity. For a vessel to give way, it is needful that there should be a difference between the tension of the blood within it, and the pressure of the parenchyma outside it; now in the liver, any degree of tension, however excessive, is at once transmitted from the vessels to the secreting network. There is no room for the blood to escape. Hæmorrhage into the liver only occurs when abnormal cavities, into which the blood can be poured, have been produced by accident or disease. The extreme stagnation which we have referred to as the first stage in embolic abscess, may however be regarded as equivalent to an extravasation, to a hæmorrhagic infarction. For it would appear that the circulation is quite as incapable of being restored in these cases, as in the hæmorrhagic infiltrations of other organs; the whole of the affected portion of the liver dies and becomes a *caput mortuum*, towards which the subsequent inflammation and suppuration stand in the relation of secondary, reactive or sequestrating processes. As is seen in the annexed drawing (fig. 143) the limits of stagnation coincide most strictly with those of the hepatic lobules. The sequestrating inflammation and suppuration are also limited, at least in their beginnings, by the marginal boundary of the lobules. To a distance of 2 to 3 lines all round the congested part, the lobules are swollen and of a greyish hue (fig. 143, *b*). For the most part, they present the characters of the parenchymatous inflammation described above;

the secreting cells of those lobules which adjoin the healthy tissue being in a state of œdema and cloudy swelling. Those lobules on the other hand which adjoin the congested part, are in a very different condition. They are permeated by innumerable pus-corpuscles, and are evidently on the way to complete liquefaction. The pus-corpuscles lie between the rows of secreting cells, outside the capillary walls. Our former views would have led us to derive them from the proliferation of the capillary nuclei; and in this particular case I am loth to adopt the modern theory (*see* above); for, as may be seen in preparations which have been pencilled out, the colourless cells form little aggregates disposed alternately along the vessels—an arrangement which forcibly recalls that of the capillary nuclei. I have not been able to discover that the hepatic cells take any active share in the pus-formation; but it seemed to me as though the disorganisation were coincident with the disappearance of their protoplasm and the liberation of their nuclei.

FIG. 143.



Embolic abscesses of the liver, after *Frerichs*.* *a*. Zone of stagnation; *b*. Zone of parenchymatous inflammation; *c*. Normal parenchyma; *v*. Hepatic vein.

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* *Frerichs*, as is justly remarked by *Klebs*, does not recognise the "embolic" character of the deposit which he figures. Nevertheless his figure agrees so perfectly with the appearance of those embolic deposits which I have myself investigated, that I thought it hardly worth while to handle the matter afresh.

So much for the first stage of embolic hepatitis, during which it differs from the thrombotic variety. Thrombosis of the portal vein, so far at least as its branches are included in the domain of the abscess, now associates itself with the inflammatory changes, and the suppuration is concentrated, in the manner described above, round the portal canals. Abscesses which have outrun the limits of a cubic inch, cease to be anatomically distinguishable from one another; provided of course that they are still in progress, still extending.

§ 507. I have already suggested that IDIOPATHIC ABSCESS of the liver may represent one of the terminations of acute parenchymatous hepatitis. I based this view partly on the occurrence of isolated corpuscular infiltrations in parenchymatous hepatitis, partly on the presence of the latter affection in the initial stages of embolic abscess. The reason why our information on this point is so inadequate depends on the rarity of idiopathic abscess of the liver in European countries; it is endemic in India and on the African coast. The disease runs an acute course, with fever, jaundice, and enlargement of the liver. After death, colossal accumulations of pus are often found in the thickest parts of the organ, particularly in the hinder part of the right lobe.

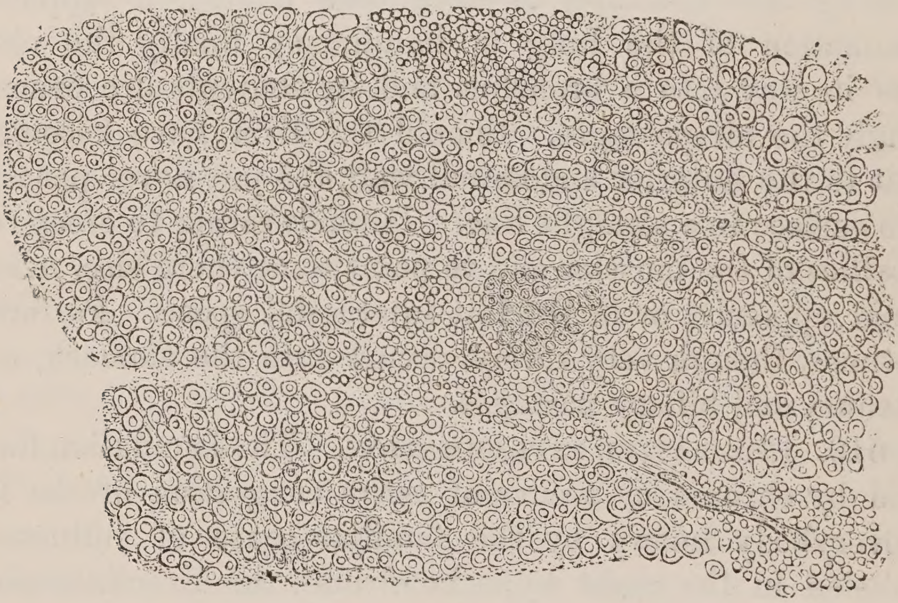
§ 508. TRAUMATIC ABSCESS of the liver has recently been investigated afresh. On the third or fourth day after irritating the liver with red-hot needles, &c., *Köster* found dense aggregations of colourless blood-corpuscles surrounding the divided vessels in the interlobular connective tissue. The columns of hepatic cells recede from one another, colourless blood-corpuscles occupying the intervals. *Holm* assumes that the liver-cells also take an active share in the suppurative process. Upon the whole, traumatic suppuration of the liver appears to follow the analogy of the thrombotic variety.

§ 509. The further course of hepatic abscess is the same in all cases. It becomes a question whether the abscess, owing to progressive liquefaction of the parenchyma, will reach the surface of the organ at some point or other, or whether the pyogenic layer will be thick enough to resist the chemical action of the decomposing pus before any such catastrophe can occur, and go on to produce a capsule of tough connective tissue. In the latter, fortunate event, the pus-formation gradually subsides; what pus there is, becomes inspissated and is finally absorbed, leaving a small cheesy or calcareous residue. The fibrous capsule shrinks into a stellate cicatrix, which cannot of course adequately replace the very considerable loss of substance. Should the abscess, on the other hand, go on increasing, it reaches the capsule of the liver; inflammatory adhesion of the latter to the opposite surface of the peritoneum may ward off the risk of perforation into the abdominal cavity; for this, however, the adhesion must be tolerably firm, as the pus has often been known to rupture a feeble adhesion, and so to force its way into the peritoneal sac. Granting this danger to be past, the adhesion guides the suppurative process step by step to other organs. The diaphragm is most commonly perforated, at the risk of setting up pleurisy; supposing this risk also to have been eluded, a suppurative inflammation of the lung is imminent; finally the abscess makes its way into a bronchus and its contents are evacuated through the air-passages. Should the liver have become adherent to the anterior abdominal wall, the pus never penetrates to the surface in a straight line. It tends rather to creep round the bellies of the muscles and to point somewhere else, near the xiphoid appendix or in the last intercostal space. Perforation sometimes, though very rarely, occurs into the stomach, colon, duodenum and biliary passages.

§ 510. INDURATIVE INFLAMMATION. The foundation for this is laid by chronic or recurrent *active* congestion of the liver. As everybody knows by the familiar sense of fullness and oppression in the right hypochondrium, the liver increases in bulk after every meal; moreover it has been proved by vivisection that the liver shares in the digestive hyperæmia of all the abdominal viscera. Improper food, pungent condiments, and above all, alcoholic excesses, render this physiological hyperæmia abnormally intense; it subsides less completely after each recurrence, until at last it becomes chronic. Intermittent fever likewise gives rise to an active congestion of the liver, characterised by the very marked enlargement, or as it used to be called "*engouement*" of the organ (ague-cake). In either case it is of the first importance that the physician should restore the organ to its normal size while the condition of hyperæmia is still uncomplicated. Otherwise they both inevitably lead to a lasting and absolutely irreparable organic change, which manifests itself broadly as an overgrowth of the interlobular connective tissue.

It is quite possible that here, as in suppuration, the change may partly depend on an immigration of leucocytes from the vessels, especially from the interlobular twigs of the portal vein. We have hitherto been content to trace indurative inflammation from its starting-point in an accumulation of young cells immediately around the portal vessels. In a preparation given to me by *Billroth*, clusters of embryonic elements may be seen at the points of junction of three or more lobules; they correspond therefore in position to the terminal branches of the portal vein; and according as the portal canals have been divided transversely, obliquely, or longitudinally, they present the form of circular, elliptical or branching figures (fig. 144). It is seldom indeed that we have an opportunity of observing the overgrowth of the interstitial connective tissue at so early a stage. As a general rule, we find the portal canals occupied by a connective tissue principally made up of fibres, and containing but few corpuscular elements, a tissue structurally homologous with that of a cicatrix. True embryonic tissue is either wholly absent, or only appears in the form of a narrow belt intercalated between the cicatricial tissue (*a*) and the parenchyma (*b*), (fig. 145). The latter appearance is very common; it gives us some insight into the mode of extension of the hyperplastic tissue, into the

FIG. 144.

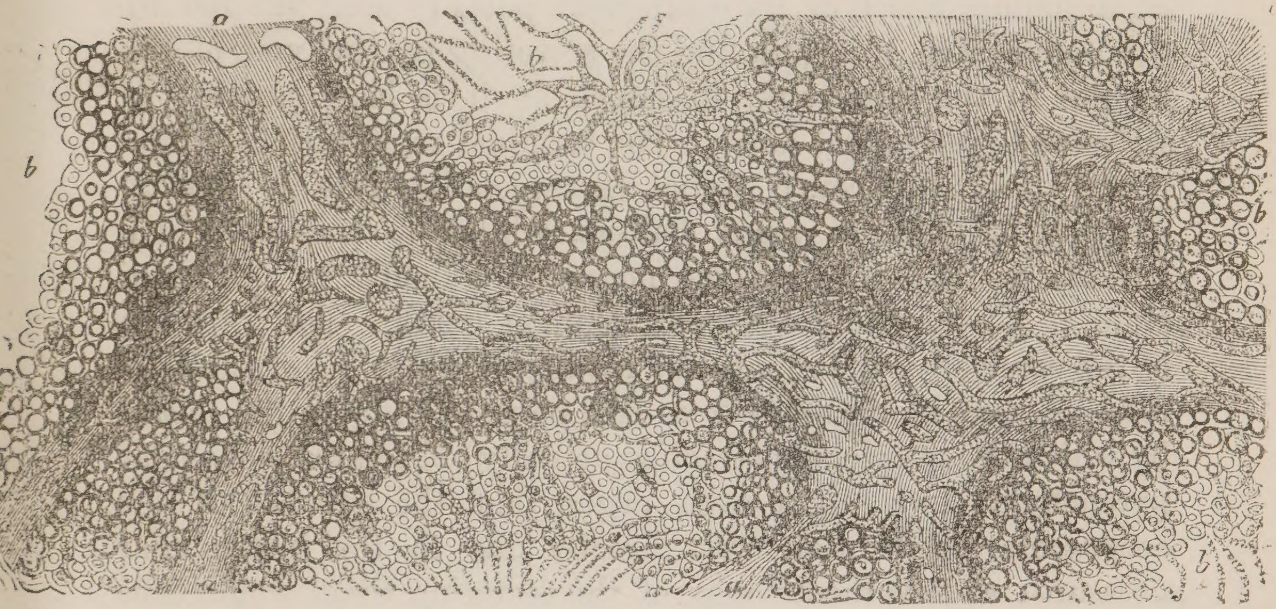


Indurative hepatitis. First stage. *a*. Interlobular vessels surrounded by an infiltration of small cells; *v*. Intralobular vessels. $\frac{1}{300}$.

"stadiology" of the process. The elements primarily infiltrated (fig. 144) into the portal canals, have already been converted into cicatricial tissue. This transformation begins in the centre of the deposit, in the immediate neighbourhood of the portal vessels, and extends gradually outwards. In the meantime, and before the whole of the existing embryonic tissue has been converted into fibroid tissue, the corpuscular infiltration has also increased and spread, forming a marginal zone which intervenes at all points between the cicatrix and the parenchyma.

§ 511. It is obvious that these newly-formed products must interfere very much with the secreting tissue of the liver. They do this chiefly in two ways. First, the young connective tissue invades the adjoining lobules; this may be seen wherever the zone of infiltration, so often alluded to, is at all well-marked. The liver-cells disappear in proportion as the young connective-tissue elements force their way along the capillary vessels, and between the columns of secreting cells. Step by step, single lobules or whole groups of lobules which are included between any two or three adjacent portal canals, are destroyed. No sooner have they ceased to exist, than the deposits of embryonic

FIG. 145.



Indurative hepatitis. Second stage. *a a.* Broad bands of fibrous connective tissue, permeated abundantly by vessels without proper walls, and separated from *b* by an interrupted layer of young connective tissue; *b.* Groups of lobules, infiltrated with fatty matter at their edges. $\frac{1}{200}$.

tissue, advancing from all sides, meet and coalesce, just as the waves close over a drowning man; nothing being left of the hepatic structure beyond connective tissue and vessels.

A second, and upon the whole, an even more efficient factor in the disorganisation of the secreting substance, is the constricting force exerted by the connective tissue during its fibroid transformation. The "cicatricial contraction" (§ 93) is eminently marked in the present case. Its action increases progressively in power as we pass from the finest divisions of the portal canals to their main branches and finally to their trunk. The inevitable consequence is a contraction of the entire organ, a shrinking of the liver in all its dimensions. If we go on to inquire which of its component parts is most affected by this contraction, we again find the secreting parenchyma of the lobules in the first rank, inasmuch as it is least adapted to withstand mechanical force. The terminal ramifications of the portal canals are coiled round corresponding bits of hepatic parenchyma like so many halters, while the traction which steadily tends to tighten the nooses, and finally to run them close, is propagated from their common trunk. The intrusion of the connective tissue into the lobules, to which I have already referred, may be regarded from this point of view as the means by which the interlobular traction actually obliterates the lobular parenchyma; we might even argue that the advance of the corpuscular infiltration was directly due to the interlobular pressure; so that the atrophy of the secreting tissue would thus be ascribed to a single connected process instead of two independent factors.

§ 512. So much for the textural changes which invariably recur in the same order in all forms of indurative hepatitis. We can distinguish broadly between three varieties of the disease—the indurated, the granular and the lobulated liver. The occurrence of one or other of these forms is determined by the localisation of the connective-tissue development either in the finest ramifications of the portal tree, or in its medium-sized divisions, or finally in its main branches.

INDURATION OF THE LIVER. A uniform contraction of the organ in all its diameters associated with a marked condensation of its texture, with a wooden rigidity and dryness, with a diminution in the size of the individual lobules which are framed in whitish strips of connective tissue—these are the changes, which, taken together, make up what we call "induration of the liver" *par excellence*. The overgrowth of the connective tissue is distributed with the utmost uniformity throughout the whole interlobular system; each lobule is separated from its neighbours by a fibrous septum, each is individually exposed to the wasting pressure of the cicatricial tissue; and this is the reason why we fail to observe, in contrast to the cirrhotic liver, any protrusion of the relatively healthy parenchyma above the level of the external or sectional surface, and why the indurated liver seems but slightly granular.

Induration of the liver is most common as a sequela of long-continued ague. Thus we occasionally find it associated with another series of structural alterations, referred to in § 184, *sc.* the formation of melanæmic pigment in the liver. When this takes place, the indurated organ is slate-coloured, and we can see black flakes of pigment in large numbers round the portal veins and capillary vessels. These flakes are either the remains of hæmorrhages which have previously occurred, or they may have penetrated through the walls of the vessels in their existing form. In any case, they ought never to be mistaken for wasted liver-cells; for they are always situated between the pervious capillaries and the intact columns of hepatic cells, thus presenting all the appearance of having been "infiltrated," of having "forced their way in."

§ 513. Granular liver (Cirrhosis). Should the growth of connective tissue be restricted to the portal canals of large and medium calibre, proportionately larger segments of the secreting parenchyma will be included and "laced off." The entire mechanical effect of the indurative inflammation is concentrated in particular directions; all the lobules which lie in these directions are utterly destroyed; the adjacent ones suffer to a greater or less extent; while the intermediate portions of the parenchyma continue relatively normal, though they are subjected to a degree of lateral pressure which makes them bulge outwards wherever they can find room to do so. The entire surface of the cirrhosed liver is accordingly studded with hemispherical elevations, which vary in proportion to the size of the parts "laced off," from the dimensions of half a millet-seed to those of half a filbert, or more. This "granular" aspect is also, though less distinctly, presented by the cut surface of the recent liver. The granular elevations are not therefore, as *Laennec* erroneously supposed,* the diseased part; it is the connective tissue between them which is abnormal; indeed they represent what is left of the healthy parenchyma.

In speaking of the hepatic parenchyma as "healthy," my words must not be taken too literally. The secreting cells are very commonly fatty; where they adjoin the fibroid tissue, they often exhibit an intense degree of pigmentary infiltration, which may reasonably be regarded as a part of the disorganisation which is here in progress. We are most struck, however, with a singular disorder in the ranks of the secreting cells, which makes it impossible to distinguish the limits of the individual lobules, and so to ascertain how many of them are contained in each of the granular nodules.

The hyperplastic connective tissue likewise merits a more detailed consideration. Its analogy with the fibroid tissue of scars, to which I have already referred, might leave the reader under the impression that it is scantily provided with vessels. Quite the contrary; the white, scar-like tissue is abundantly permeated by blood-vessels, which, in well-injected specimens, may leave us in doubt whether they, or the hyperplastic tissue take up most space. These vessels cannot be shown to possess a proper lining membrane; instead of it, we find the most superficial stratum of the connective tissue covered with a single layer of epithelium; this gives the entire structure a certain likeness to cavernous tissue. These peculiarities are undoubtedly connected with the great vascularity of the normal liver. It is only on condition that the greater part at least of the blood which continues to flow to the liver shall find a passage through it, that fibroid changes of any magnitude can be permitted to occur within the organ. Much of course depends on the tension of the affluent blood; this is very much higher in the hepatic artery than in the portal vein or its branches; hence the curious fact that the lacunar spaces in the fibroid tissue, as is shown by injection, receive their blood, not from the portal vein, but from the artery. The portal vein is often found obliterated from its medium-sized divisions onwards. In one case, the greatest force I could exert did not enable me to fill more than the trunk and its three or four main divisions, from the portal vein. These proved moreover to be much dilated, and a more thorough investigation showed that the portal blood had not been transmitted through the liver at all, but had passed directly into the inferior cava through a number of dilated anastomoses between the mesenteric and spermatic veins. In other cases, the portal blood flows immediately into the granular islets of parenchyma, from whence it makes its way into the lacunar system of the cicatrices, while the latter can be directly filled from the hepatic artery.

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* *Laennec* identified them with cheesy tubercles.

The distribution of blood in the cirrhotic liver seems to be chiefly regulated: (1) by the compression and obliteration of the branches of the portal vein by the cicatricial tissue, while (2) the area of distribution of the hepatic artery is steadily enlarged. The narrowing of the portal vessels gives rise to the manifold effects of passive congestion in the intestines and spleen, to ascites, &c., and determines the opening-up of collateral anastomoses between the portal vein and the inferior cava. The extension of the arterial territory allows the hepatic artery to take some of the duties of the portal vein upon it, the bile being thenceforward mainly elaborated from arterial blood.

The hepatic ducts seem as a rule to remain pervious. Sometimes, though rarely, we come across a granular islet of parenchyma, whose dark-yellow, brown, or even green colour tells us that its efferent duct has been compressed by the cicatrix, causing retention of the secreted bile. The tolerably frequent occurrence of jaundice in cirrhosis of the liver must therefore be ascribed merely to obstruction of the orifice of the ductus choledochus by swelling of its mucous lining, in consequence of a simultaneous catarrh of the duodenum.

§ 514. LOBULATION OF THE LIVER is usually associated with granular cirrhosis. Due to the same causes, produced in the same way, it merely shows what striking deformities must naturally result when the main trunk of the portal tree, together with its principal divisions, is involved in fibroid degeneration. It is then that the natural division of the liver into lobes, masked during health, and which, as we already know, is due to the grouping of the parenchyma round the larger and medium-sized branches of the veins, manifests itself more or less strikingly. The granular islets either form secondary elevations on the surface of the lobulated organ, or else we find a gradual transition from the smallest granular nodules through an ascending series of larger ones to the walnut-sized segments of parenchyma which make up the lobulated liver.*

6. TUMOURS.

§ 515. CAVERNOUS TUMOURS. The selection of subjects by pathological histologists, and the order in which they have been taken, has not always coincided with the practical needs of the physician. But for this, we might justly have wondered that while some most important questions concerning the origin and growth of cancerous tumours of the liver are still unsettled, a tumour which is utterly insignificant from a clinical point of view, the cavernous tumour, should at an early period have attracted the attention of our best observers. Not only do we possess a thorough knowledge of the minute structure of these occasional gaps in the substance of the liver, varying in size from a pea to a walnut, sharply circumscribed, filled with erectile tissue, and therefore, even when half empty, of a dark purple colour; but we also possess a theory to account for their origin and development, started by *Virchow*, and which is far more than a mere hypothesis.

§ 516. The proper substance of the tumour consists of a trabecular network of connective tissue, whose interstices are open to the blood. If we examine one of these trabeculæ under the microscope, we find that it consists of a single layer of pavement-epithelium, spread over a fibrous basis-substance which contains a limited number of spindle-shaped corpuscles, believed by some observers to be unstriped muscular fibre-cells. Networks of elastic fibres, partly surrounding, partly traversing the spaces, give the entire structure a certain resemblance to the alveolar septa of the lungs. The average size of the enclosed spaces also corresponds to that of the air-cells. As regards structure, I need only add that the septa radiate from one or more centres situated in the middle of the tumour; centres which are only distinguishable by their containing a somewhat larger accumulation of connective substance, but whose nature and significance can only be understood from a consideration of the development of the tumour.

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* Pathological lobulation of the liver must not, of course, be confounded with congenital lobulation; in the latter, there is no overgrowth of connective tissue. Again, it may be mistaken for syphilitic disease, an error for which there is some excuse, as indurative inflammation and the production of cicatrices do really form part of the latter disorder (Cf. § 521).

On examining the periphery of the tumour with the microscope, we soon discover that it is everywhere separated from the hepatic parenchyma, by a moderately wide layer of connective tissue; here and there, this connective tissue may be seen to send a three-cornered process into the interval between two adjacent lobules. These processes also contain blood-vessels; but they are less numerous, and separated by wider bridges of connective tissue. Here, if anywhere, we get an insight into the development of the tumour; it consists in an interlobular overgrowth of connective tissue, followed by cavernous metamorphosis (§ 130). The tumour is thus related to interstitial hepatitis on the one hand, to the development of fibroid tumours on the other. We found the connective tissue remarkable for its vascularity, even in cirrhosis; it was then hinted as probable, that this vascularity might depend on a local cause, viz. the enormous vascularity of the liver itself; and we may invoke the same cause in the present case also. Here it gives rise to the development of a telangiectatic or erectile, instead of a simple fibroid growth.

§ 517. This insight into the development of the tumour renders it needless to try to refer its lacunar spaces to dilatation of the pre-existing arteries, veins or capillaries. The hepatic parenchyma with all its vessels is destroyed, lobule after lobule, very slowly, but very completely, without any antecedent distortion; its destruction being due to the pressure of the growth as it extends along the smallest portal canals. With the arrest of the capillary circulation, the corresponding branches of the hepatic vein collapse, ultimately forming those denser accumulations of connective substance from which the septa of the fully-developed tumour appear to radiate, because the growth has converged from all sides towards them, *i.e.* towards the centre of the lobules.

Virchow's injections show that the lacunar spaces of the tumour may be filled both from the portal vein and the hepatic artery, but not from the hepatic vein. This, also, is explained by the development of the growth. The portal canals contain only branches of the portal vein and of the artery, and a tumour which grows in these canals will naturally get its blood from these vessels, and not from the hepatic veins, from which it is separated by the lobular parenchyma.

§ 518. The secondary metamorphoses of these cavernous tumours may be dismissed in a few words. I have once seen a partial obliteration of the lacunar spaces, undoubtedly caused by a previous coagulation of the blood contained in them. The central part of the tumour (which was about the size of a hazelnut) was occupied by a tough white nodule, as big as a pea; this nodule being surrounded by a zone, a line in width, of pervious erectile tissue. A vertical section showed, however, that the septa extended all through the nodule; so that the lacunar intervals must have been filled up by a secondary development of young connective tissue.

§ 519. CYSTS. Putting aside hydatids and accidental cysts (softened cancer-nodules, abscesses, &c.) there remains only a small group of hepatic cysts, all of which must be regarded as bile-ducts, dilated in consequence of retention. Such cysts are sometimes single and of considerable size; sometimes, though rarely, we meet with multiple cysts varying in size from those which are barely visible, to those which attain the respectable dimensions of a pigeon's egg. In common with other observers (*Rokitanski, Förster*), I have found these multiple cysts of the liver associated with extreme cystic degeneration of both kidneys. The liver, in the case I examined, was especially rich in cysts at its anterior part, the free border of the left lobe being entirely occupied by medium-sized blebs, while towards the inner and back part of the organ, the cysts were less numerous and of proportionately larger size. Accordingly, the opportunity was favourable for tracing the mode of their development.

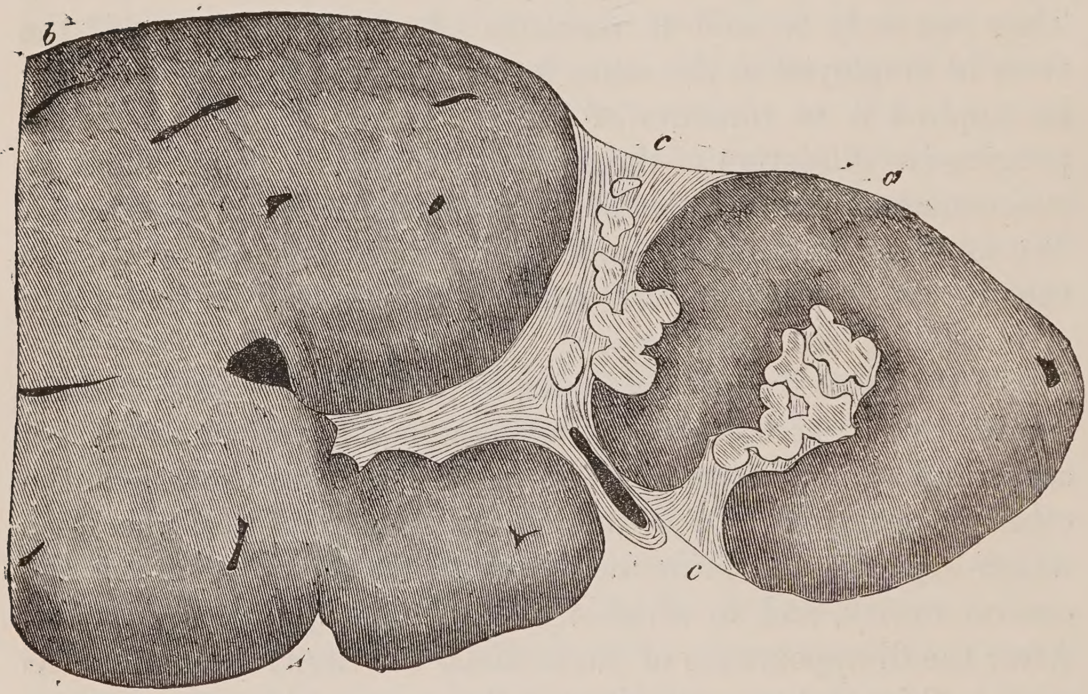
At an early period of the inquiry, I was struck with the great similarity between the first stages in the development of the cysts and the condition which *Naunyn* has briefly described as "*Cystosarcoma Hepatis.*" In the middle of certain white nodules of connective tissue as large as a good-sized millet-seed, which lie embedded in the portal canals, a punctiform orifice can be detected even with the naked eye; this proves, on more minute examination, to be simply a dilated interlobular bile-duct. These dilatations are lined by a sub-columnar epithelium which is continuous with the epithelial lining of the efferent duct; in the smallest tumours, their shape is simply ellipsoidal; in those of larger size, they bulge in various directions—nay, they are often studded with a number of tubular processes which penetrate into the adjoining parenchyma. From these appearances *Naunyn* wanted to infer that the tumour extended by epithelial sprouts, and belonged to the class of adenomata (*see* below). They can only be said to resemble adenomata, however, if the term be employed in the sense formerly given to it by *Billroth;* he applied it to tumours of the mammary gland in which a progressive dilatation of the efferent duct was brought about by a sarcomatous degeneration of the subepithelial connective tissue. We must not on that account ascribe any cancerous quality to the process, as will indeed be sufficiently obvious from its further course (Cf. § 526, *Adenoma*).

In the same liver I succeeded in finding every intermediate form between the first beginnings which I have just described, and simple globular cysts. The transition from the one to the other is operated by a reduction and perforation of the folds which separate the individual diverticula given off from the central cavity, and to which its chambered appearance is due. After the disappearance of these folds, the cavity gradually fills with a thin, watery secretion; it becomes a simple retention-cyst with smooth walls.

§ 520. Syphilis. For information concerning the general character of syphilitic growths, I refer the reader to the first part of the present manual. Syphilitic changes in the liver belong to those profounder lesions which are produced during the later stages of the disease, and which are also known as "tertiary." The anatomical alterations consist of two distinct processes, variously combined with one another; of an indurative overgrowth of connective tissue on the one hand, of a development of gummata on the other.

§ 521. The most common case is that in which one or more deposits of tough, white connective tissue are found in the parenchyma of the liver, in conjunction with analogous changes in other parts of the organism (the cranial bones, the pharynx, larynx, &c.); these deposits send radiating prolongations into the surrounding parenchyma in various directions, and are followed by a fissuring and lobulation of the surface, corresponding to and caused by vigorous contraction, operating in those directions (fig. 146). These phenomena are, as a rule, most strikingly exemplified along the attachment of the suspensory ligament; in this region we occasionally find three or more stellate cicatrices; or perhaps the entire thickness of the liver may be traversed by a single fibroid band of colossal size. It is probable that the traction, however gentle, which the ligament exerts upon the liver during its to-and-fro movements upon the diaphragm, may contribute, as a predisposing cause, to the localisation of the lesion; further details concerning syphilitic alterations in the liver will show that its co-operation is not in any way indispensable.

Fig. 146.



Syphilitic disease of the liver. *a.* Left; *b.* Right lobe; *c c.* Deposit of connective tissue which traverses the organ from its transverse fissure to the suspensory ligament, and contains gummata in its interior. $\frac{2}{1}$.

Gummatous nodules of various age and size occur, not indeed invariably, but very often, in the substance of and near the fibroid tissue: they are more rarely found alone amid the healthy parenchyma. Yellowish-white, cheesy and sapless nodules, as big as a cherry-stone, are more common than those younger and still soft formations, in which the minute structure of the specific products of syphilis admits of being studied. The latter contain corpuscular elements, some round, others spindle-shaped or stellate, which have undergone fatty degeneration, but which persist in the form of granule-cells; the round ones occupy the centre, while the stellate and spindle-shaped ones are situated at the periphery of the spheroidal nodules. The basis-substance is swollen and soft; on the addition of acetic acid it yields a precipitate of mucin. The cheesy nodules are clearly due to a further metamorphosis of these true gummata, and ought never to be mistaken for inspissated pus, cancer-nodules which have become cheesy, and so forth. Sometimes, though very rarely, these nodules undergo a further change; they soften and are reabsorbed; fortunately, however, they are usually present to prove the syphilitic nature of the radiating cicatrices of connective tissue, which might otherwise be ascribed to a wrong cause.

§ 522. The localisation of the syphilitic products in multiple foci of smaller size (from thirty to sixty) scattered throughout the entire parenchyma, is far less frequent than their occurrence in single large masses. Suppose from five to ten gummatous nodules, much smaller than a millet-seed, united into a small spheroidal tumour by means of tough connective tissue, whose basis-substance is as transparent as cartilage, and whose cells are typically spindle-shaped; the connective tissue forming an areola which sends radiating processes to a variable distance into the neighbouring textures, and gives the whole of the affected part a grey, translucent aspect. The central portion of each single nodule consists of round-cells, or even of multinuclear giant-cells which are destined to undergo fatty degeneration; moreover a kind of concentric arrangement may often be observed, such as we find in transverse sections of degenerated vessels. But it is difficult to say what vessels are here involved; for the said gummata are always situated in the portal canals, where arteries, veins, bile-ducts and lymphatics run side by side. I have succeeded in proving to my own satisfaction, by the examination of isolated nodules, lying immediately under the capsule, that we have to do with lymphatics; further observations are needed, however, to decide this point.

§ 523. A third variety of syphilitic liver is that hereditary cirrhosis which is met with in the new-born infants of a syphilitic mother. Whether the mysterious cases of typical and fully developed cirrhosis which are occasionally met with in children from ten to fifteen years of age, and which I have found to be characterised by complete obliteration of the branches of the portal vein, are a more advanced stage of the former hereditary variety, it is not easy to decide. This view is supported by the very perfect compensatory arrangements, which in these cases more than in any others, regulate the portal circulation, and which can only be explained on the supposition that the liver had to accommodate itself to its disordered condition while still in process of development.

§ 524. LEUKHÆMIC SWELLING. In treating of leukhæmia (§ 177, *et seqq.*) I laid down the fundamental characters of leukhæmic infiltrations in general. The liver is their favourite seat; and it is in the liver that their minute structure may be most satisfactorily investigated.

Ever since we have been aware of the fact that the minute vessels permit the transit of the colourless blood-corpuscles through their walls, we have been obliged to regard the "growth of lymphadenoid tissue" occurring in leukhæmic subjects as an infiltration, due to the migration of leucocytes from the vessels. Indeed the increased number of colourless elements in the blood itself is too suggestive to admit of our shutting our eyes to this possibility. Moreover, the results of microscopic examination invariably corroborate the hypothesis of emigration. Owing to the remarkable analogy in external form between leukhæmic deposits and hæmorrhagic extravasations in the kidneys, I had long puzzled my brains to discover how and whether I might refer the leukhæmic foci to antecedent hæmorrhages. I never got farther than the discovery that the vessels in the affected areas were peculiarly thin-walled, as shown by the large extravasations from them during injection of the organs. Now in the liver, we find the leukhæmic infiltration intimately associated with the course of the vessels. Every section made through a duly hardened and injected specimen shows the colourless cells arranged in rows along the capillaries throughout the entire lobule. Here and there, the cells are so closely aggregated as to give one the impression of an epithelial layer in contact with the outer surface of the capillaries; this is especially the case in the marginal part of the lobules; less so towards their centre. It may be taken for granted that this infiltration—like fatty infiltration, *mutatis mutandis*—invades the lobule from without inwards. The secreting cells take no part in the process. Separated from the vessels, the source of their vital and functional activity, they become atrophied; a brownish mottling of the hepatic tissue may often be observed even with the naked eye, due to little heaps of pigment-granules, the remains of former liver-cells. This mottling is all the more apparent, as the colour acquired by the lobule in consequence of leukhæmic infiltration is a very pure milk-white. We are usually able to see all stages of the morbid change in the same liver, since the boundaries of the individual lobules are in no degree effaced by the advancing infiltration, but rather made sharper and more distinct. So that by the side of normal lobules we see others whose edges are slightly swollen and pale; others again which are increased by about one-third of their normal size, and of a uniform greyish-brown tint; finally some milk-white lobules of monstrous dimensions, peculiarly dry, and bulging outwards when cut across. The various degrees of infiltration are usually so distributed that the parts of the organ which are most exposed to pressure (*e.g.* under the edge of the ribs) are least altered, while the parts farthest removed from these present a higher degree of morbid change; to this rule, however, there are many exceptions. A rare variety of leukhæmic disease of the liver consists in the presence of circumscribed greyish-white nodules which in some respects resemble miliary tubercles, differing from them however in their softer consistency. The nodules are situated in the portal canals, and are for the most part associated with the infiltration previously described.

The size and weight of the leukhæmic liver may be very great, even equal to those of the cancerous liver (fig. 150, VIII.). Leukhæmic livers have been met with weighing 14 pounds.

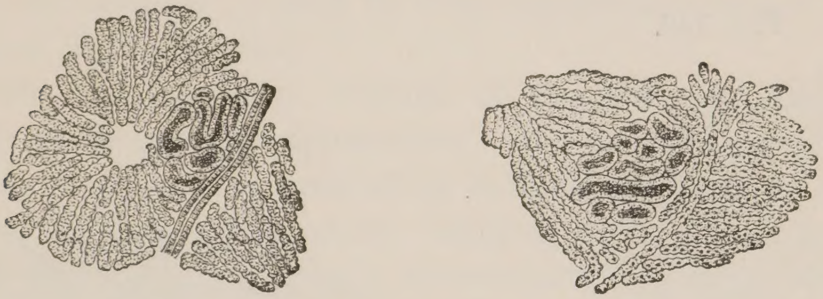
§ 525. TUBERCLE. In general tuberculosis of the serous membranes, the lungs, the heart, &c., such as is most commonly met with in children, a variable number of miliary nodules may also be found scattered through the liver. They are developed upon the smallest ramifications of the hepatic artery; hence they are not confined to the interlobular spaces, but occur also in the interior of the lobules, where they make room for themselves by pushing the parenchyma aside. According to *Schüppel* (Archiv der Heilkunde, Bd. ix. Heft. vi.) the corpuscular elements of which these tubercles consist are developed, not on the outside, but in the interior of the blood-vessels. Supposing this to be true, I should feel inclined to derive them from a proliferation of the endothelium, inasmuch as I have been able to observe this mode of origin in the lymphatics and the serous membranes (*see* § 115). *Schüppel,* on the other hand, regards the tubercle-cells as the direct progeny of white blood-corpuscles, and totally repudiates the view that they originate from the endothelia, with whose proliferation he is quite familiar, from his investigations on cancer.

Even should the tubercles in the liver, as occasionally happens, attain very considerable dimensions, they nevertheless remain of very subordinate local importance. The larger ones are often found to be cheesy at their centres, their caseation being followed by imbibition of bile; dead tissues being prone to absorb pigmentary matters which they reject while living.

§ 526. ADENOMA. True epithelial cancer of the liver is exceedingly rare; it is always secondary, and occurs in the form of very minute nodules. Adenoma, on the other hand, though equally rare, is always primary, and seems in some measure to replace the ordinary epithelial cancer. Since *Rokitanski* first directed attention to the occurrence of a tumour-like deposit of newly-formed hepatic tissue, more recent observers have often met with it. After eliminating, on *Hoffman's* recommendation, those cases of superfluous development of true hepatic tissue in small globular masses, which possess a merely teratological interest, we have left, as an "Adenoma hepatis," a tumour characterised by extremely marked features, both naked-eye and microscopic. The former, however, may be so immediately deduced from the manner of its origin and growth, that I will consider both sets of characters together.

If we trace the nodules to their smallest rudiments, such as are invisible to the naked eye—(this has hitherto been done in a solitary case of multiple adenoma of the liver)—we find them represented by circumscribed changes in form and colour in the interior of single lobules (fig. 147). If the specimen has been previously steeped in carmine fluid, we find the diseased portion of the parenchyma very deeply stained; this makes it twice as easy for us to notice that at these points the anastomosing trabeculæ of the secreting network are replaced by independent, roundly-oval cylinders of cells, which are elaborately convoluted, and occupy a space which is, upon the whole, globular; this space taking up one-sixth part of a lobule without pushing the adjoining columns of hepatic cells aside, *i.e.* simply replacing them. This primary alteration is due to a separation of the trabeculæ of the secreting network from one another at their junctions, within the affected area of the lobule; the detached trabeculæ, each for itself, assuming the form of a cylindrical aggregate of cells, such as we only meet with during the development of the open glands and in epithelial cancer. This transformation is associated with a moderate proliferation of the liver-cells; the effect of this, however, being provisionally annulled by a simultaneous diminution in the size of the individual elements.

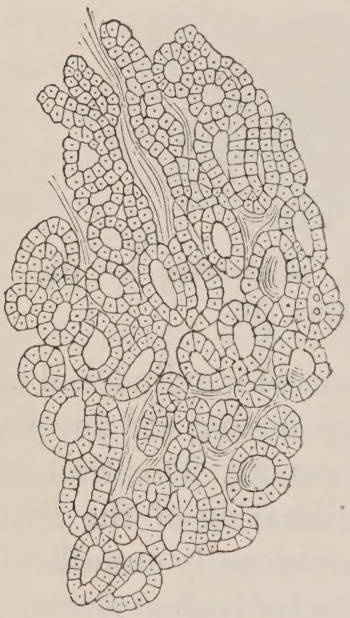
Fig. 147.



Adenoma of the liver. Smallest nodules, originating by the partial metamorphosis of a lobule. $\frac{20}{1}$.

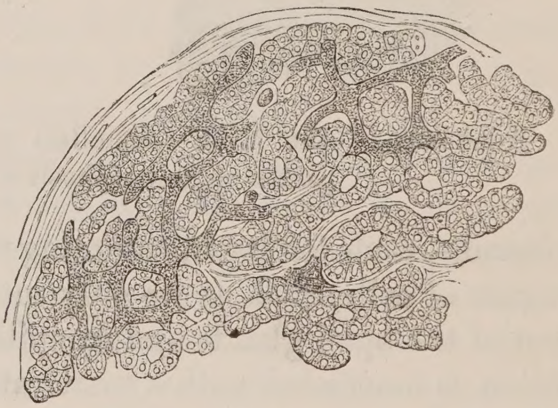
§ 527. The further growth of the nodule takes place partly by a centrifugal extension of the morbid process, partly by the proliferation of the existing corpuscular cylinders. As soon as the tumour has reached the size of a pin's head, its growth continues in the latter mode exclusively. It acquires a capsule of connective tissue, which isolates it from the surrounding parenchyma. The latter is simply pushed aside and compressed—unless it take part in the morbid process by becoming converted into fresh nodules. The original nodules, from this time forward, grow independently. The peculiar tendency which manifests itself in the earliest rudiments of the tumour, now goes on to mimic the structure of a tubular gland, such as the kidney. Figs. 148 and 149, both of which represent sections through nodules no bigger than a hemp-seed, exhibit central *lumina* of various sizes in most of the pseudo-glandular tubes; these *lumina* being filled with a yellowish jelly, or a clear, watery fluid. It must be remarked, however, that this acme of development is seldom reached, and that the process usually terminates in the production of *solid* cylinders. Fig. 149 includes a portion of the capsule of connective tissue which bounds the nodule externally. This capsule, in nodules of the size of a cherry and upwards, is smooth within, and lined with serous epithelium; so that the periphery of the nodule is really limited by a serous space, which is only bridged over here and there by the afferent and efferent vessels. Attempts to inject these tumours have shown me that their blood-channels, though originally forming part of the capillary network of the lobule, and therefore in communication with all the three main vessels of the liver, are more and more exclusively supplied from the hepatic artery as the development of the tumour goes on. The larger nodules could only be injected from the artery. We shall find something of the same sort in the true cancers.

FIG. 148.



Adenoma of the liver. Tubular structure of the growth. $\frac{1}{300}$.

FIG. 149.



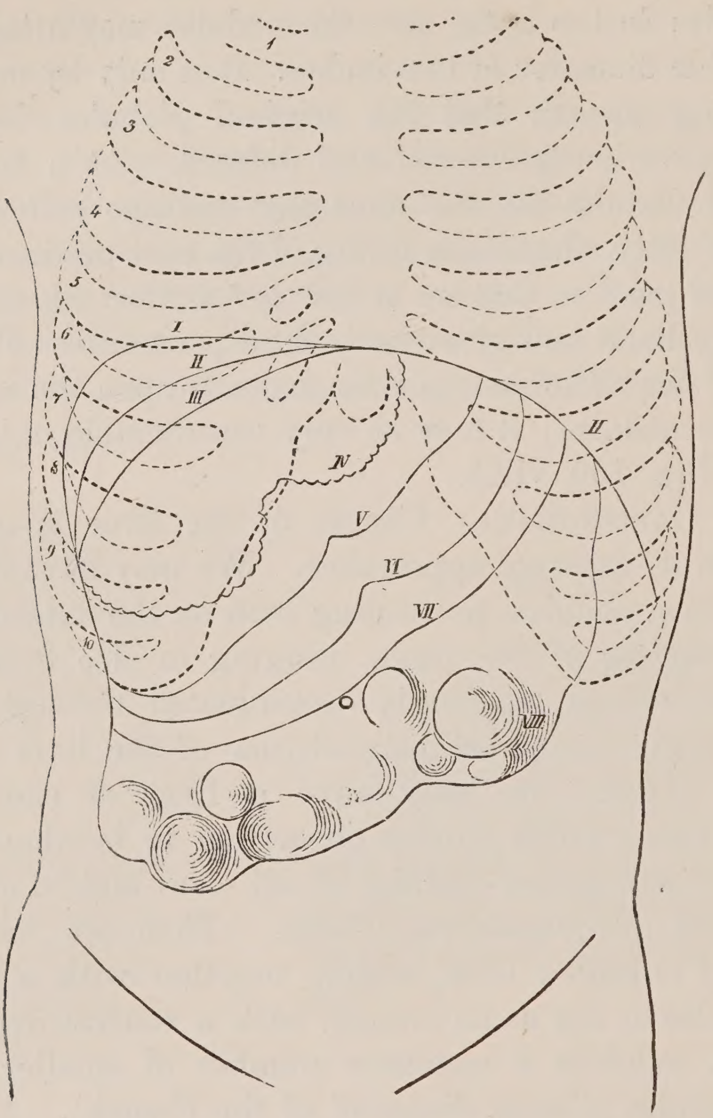
Adenoma of the liver. Blood-vessels, and capsule enclosing the tumour-nodules. $\frac{1}{300}$.

The fully-developed nodule of adenoma is therefore a globular, isolated tumour, enclosed in a membranous capsule of connective tissue; its consistency is soft and elastic, its colour a bright liver-brown, in some nodules even darker. The tumour may be single or multiple; in the latter case the nodules may attain the very considerable diameter of two inches. It is only by mutual pressure during growth that the original globular form of the nodules is variously altered and defaced. At a later period, individual nodules for the most part undergo softening; their cells grow fatty, the serous lining of the cyst produces a certain quantity of pus; so that we at last get perfect abscess-cavities, which may burst and give rise to fatal peritonitis. The size and weight of the adenomatous liver depends upon the number and size of the nodules; it may be very considerable indeed, just as in cancer (fig. 150, viii.).

§ 528. CARCINOMATA. Cancer of the liver is exceedingly variable in its external appearance. We may have milk-white, tolerably firm nodules, protruding both on the external and the sectional surface of the organ, ranging in size from a millet-seed to an orange, sparingly disseminated through the dark reddish-brown, atrophied parenchyma of the liver (*carcinoma simplex*). Again, we may have a liver of enormous size (fig. 150, viii.), which proves on section to be almost entirely made up of soft cancer-nodules of all sizes and in all stages of development (*carcinoma medullare*). Then we may have a moderately enlarged liver, which, together with a few superficial nodules as big as an orange, with a central depression or umbilicus, exhibits a countless number of smaller and very minute nodules (*Cancer disseminé* of the French). Further, we have the rare case of a true *diffuse infiltration*, in which the lobules retain their form, but grow thicker and broader, assuming more of a greyish-white, and finally a perfectly white colour. Next we have the *radiating cancer* (*Strahlenkrebs*) characterised by the concentration of the cancer-structure in bands which radiate from the centre of the nodule; this is usually a pigmented variety of medullary cancer. Finally we meet with *colloid cancer*, which is rare, and only occurs in isolated nodules of a secondary (metastatic) character.

§ 529. In attempting to master the manifold varieties here enumerated, it is very natural that we should recur to their respective origin and histological development, in the hope that this knowledge may enable us to understand, first their minute

FIG. 150.



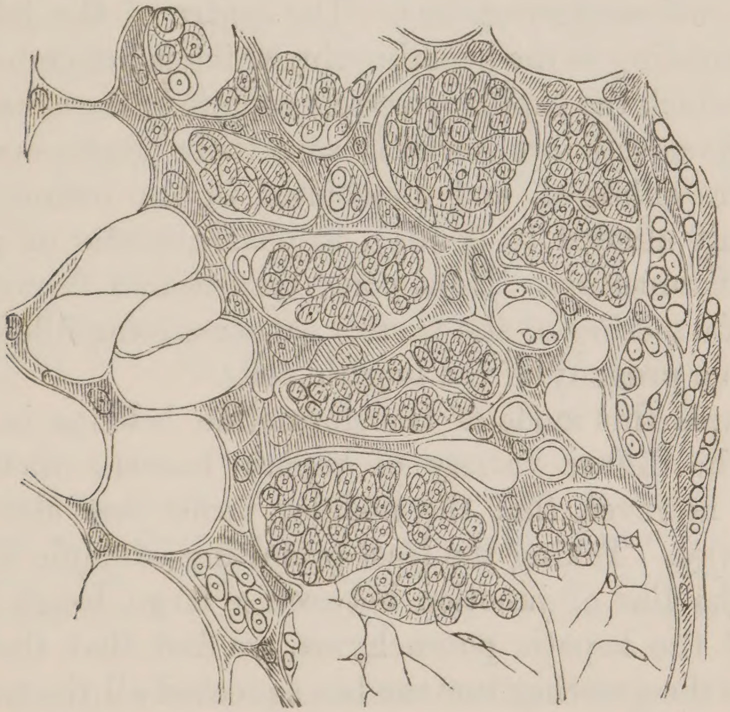
Size of the liver in various diseases. 1—10, ribs; I. Position of the diaphragm in extreme enlargement of the liver (cancer); II. II. Normal position of the diaphragm; II. III. Relative dulness on percussion; III. Position of the diaphragm on the anterior wall of the chest, indicating also upper limit of dulness of the healthy liver; IV. Edge of the liver in cirrhosis; V. In health; VI. Fatty liver; VII. Amyloid liver; VIII. Cancer, leukhæmia, adenoma. All the above are averages.

structure, and then their coarser features. This method is so very obvious that it has already been adopted over and over again; hitherto it has only availed to bewilder us in a primeval forest of isolated phenomena, which will give to future observers many an opportunity of distinguishing themselves.

Let us start from the fact that more than three-fourths of all cancerous growths in the liver are of metastatic origin; that of these metastatic deposits again, two-thirds are secondary to primary cancer in the portal area, while one-third is secondary to primary cancer in the rest of the body, both with and without previous implication of the lungs. The numerical preponderance of metastatic cancers may possibly be due to the entrance of cancerous emboli into the portal vein or the hepatic artery. In support of this view we have a series of cases of cancerous thrombosis of the vena portæ recorded by various authors. According to *Virchow* there is a perfectly independent form of cancer, which originates in the interior of the portal vein, and is not propagated from cancerous tumours in its neighbourhood. A thrombus extending from several branches at once into the trunk of the vein, without perforating its wall at any point, is found to consist wholly of cancer-tissue. This appearance can only be explained by supposing that one or more cancerous emboli have caused thrombosis in the portal vein, followed by a cancerous metamorphosis of the clot. This rare and curious phenomenon must never be confounded with the far commoner case in which a cancer of the liver involves the portal vein, destroys its walls and then proceeds to extend in its interior. On the other hand, an observation of *Naunyn's* has more claim to be considered in connexion with the present subject; he found a primary cancer of the kidney with cancerous thrombosis of the superjacent veins of the mesocolon, associated with a number of spots in the liver, none larger than a millet-seed, each of which proved to consist of a branch of the portal vein transversely or longitudinally divided, plugged with a cancerous clot, and surrounded by a very minute cancerous tumour. We might reasonably suppose this to be a perfect example of cancerous embolism, and of its destructive action on surrounding parts. Yet I feel bound to warn the reader against applying this theory too widely, inasmuch as appearances of this kind are not by any means so common as the author in question seems to believe. We can only regard the general fact as established, that in very many cases where the cancer takes the form of multiple isolated nodules, these nodules are situated in the portal canals. This, however, is equally true of nearly all tumours of the liver, and is probably connected with circumstances of another order altogether.

§ 530. A very interesting observation, which transfers cancerous thrombosis of the greater vessels with its attendant problems to the capillaries of the parenchyma, is that concerning the development and growth of the PIGMENTED RADIATING CANCER (*Strahlenkrebs*). The peculiar structure of these tumours is due to the fact that the capillary vessels, as far as their junction with the hepatic veins, are plugged with the black cancer-cells; hence the peculiar whorled arrangement, which characterises this portion of the vascular apparatus, is manifested in black stellate figures of all possible sizes. Fig. 151 represents the periphery of a cancerous nodule. We distinguish stroma and cancer-nests; the main trabeculæ of the stroma, however, contain liver-cells, some of which are much distorted and stretched, here and there abundantly stained with brown and black pigment, but whose real nature is nevertheless recognisable, partly by well-known features, partly by their direct continuity with the contiguous portions of the secreting network. The finer trabeculæ of the stroma consist of spindle-shaped and stellate cells, which of course have nothing to do with the liver-cells. The presence of liver-cells in the main trabeculæ, however, proves only that it is *not* from them that the cancer-cells here originate (in contrast to ordinary cancer); it also serves as a clue to the place where the cancer-cells really *are* deposited. Now this is no other than the interior of the blood-vessels. We can recognise the double contour of the capillary membrane where it surrounds the smaller cell-nests completely, the larger ones at least in part; accordingly it is quite certain that the cancer-cells are actually situated in what once was the path of the blood-corpuscles. The next point is to determine how they got there, to discover their origin. Till quite lately, I should not have ventured to give any decided answer to this question. I kept my opinion to myself; it was this: I believed that the cancer-cells were the actual progeny of the corpuscular elements of the capillary walls; for the appearances which are characteristic of this mode of origin—*sc.* division of nuclei and double nuclei in the interior of cells intimately adherent to the wall of the vessel, forming crescentic projections into its interior, cells lying on the inner wall of the vessel like a proliferating epithelium;—such appearances as these are plentiful at the edges of the cancer-nodule; the annexed figure shows them here and there. Nevertheless, I hesitated to proclaim my belief, until the recent beautiful researches of *Thiersch* and *Buhl* rendered the fertility of the epithelial elements of the vessels in the highest degree probable. *Thiersch* ascribes a leading share in the organisation of thrombi to these epithelial elements. *Buhl* proves that the pus contained in the twigs of the portal vein in *Phlebitis thrombotica* (*see* § 505) is produced by a proliferation of the vascular epithelia. Supported by these observations, I no longer hesitate to ascribe the origin and accumulation of cancer-cells in the interior of the vessels, characteristic of the radiating form of pigmentary cancer, to a proliferation of the vascular epithelia; and I am happy to say that the beautiful researches of *Schüppel* and his pupils on the histogenesis of cancer of the liver (*Fetzer*, Inaugural thesis, 1868) have fully confirmed this view. *Fetzer* is inclined to

FIG. 151.



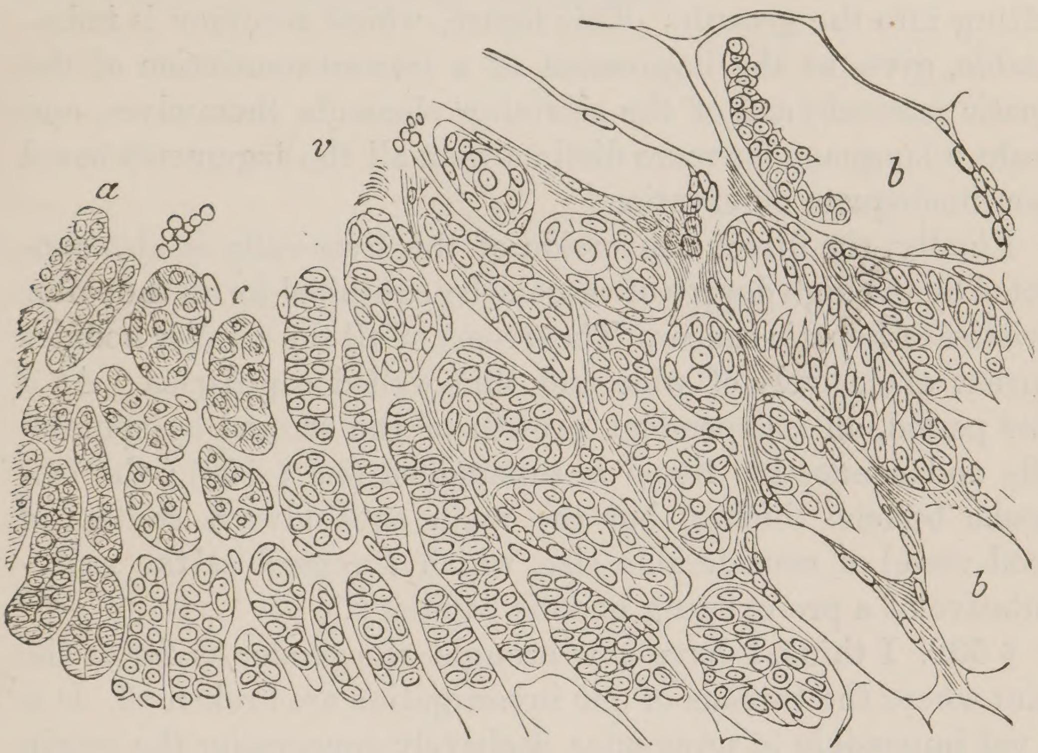
Carcinoma hepatis. Origin and structure of the pigmented radiating cancer. The first rudiments of a stroma are formed by the secreting network, while the cancer-cells are deposited in the interior of the vessels. $\frac{1}{400}$.

assign an intravascular origin and development to most of the secondary forms of hepatic cancer.

§ 531. The observation recorded in the foregoing section brings us to a second series of studies more immediately directed to the growth of the cancer-nodules. The plainest and least complicated opportunity of investigating this point is afforded by DIFFUSE CANCER OF THE LIVER, that curious degeneration of the lobules, in consequence of which they are gradually transformed into cancerous matter, while retaining in the main their original shape and outlines. Fig. 152 represents the most instructive portion of a lobule, half of which has already undergone degeneration. I believe that it will readily convince the observer that the liver-cells are directly converted, by repeated fission and change of form, into cancer-cells, while the capillary network forms the rudimentary stroma. The centre of the lobule is at *v*—corresponding to the hepatic vein, which is here much dilated, and from which the capillary vessels radiate in the usual manner. At *a* the liver-cells are normal; at *c* their angles are rounded off, they are enlarged, and dissociated in the manner which I have already alluded to (§ 501), as characteristic of parenchymatous inflammation. Next come transitional forms; at *b* we see the wide meshes of the perfect cancer-stroma filled with the innumerable progeny of the hepatic cells.

Of course this mode of transformation belongs in the first place to the diffuse variety of hepatic cancer; there can be no doubt, however, that the nodular forms *may* also grow in the same way. Taking the least promising example first: if we examine the line of junction between a large, tough nodule of cancer and the hepatic parenchyma, we find that the pressure exerted by the growing tumour has squeezed all the neighbouring lobules out of shape, and converted them into shallow disks which lie parallel with the spheroidal surface of the tumour. The cancer is girdled by five or more concentric rows of liver-cells. The impression left on our mind by these appearances is, that the liver-cells tend rather to hinder than to assist the growth of the nodule; and this view derives support from the fact that these very nodules offer the most typical example of the "*per saltum*" extension of tumours. Beyond the zone of liver-cells, and not at first connected with the primary nodule, a new one springs up; this grows independently in all directions, and finally coming into contact with the primary nodule, coalesces with it. We often find the primary nodule quite surrounded by secondary nodules of this sort; and its irregular and bulging outlines show that these are by no means the first "secondary foci" which it has annexed. From all this we cannot infer more

FIG. 152.



Carcinoma hepatis. Origin and structure of the diffuse form of medullary cancer. The vascular network is the first rudiment of a stroma, while the liver-cells are converted into cancer-cells. *a.* Normal liver-cells; *c.* Parenchymatous inflammation; *b.* Nests of cancer-cells; *v.* Vena centralis. $\frac{1}{400}$.

than that the liver-cells may waste under the pressure of the cancer, before they can assert their vitality by taking part in the metamorphosis. The possibility, however, of the cancerous elements of these smaller nodules having been immediately derived from liver-cells, remains exactly where it was.

Results very different, and far more favourable to the view under discussion, are afforded by investigation of the softer varieties of multiple cancer, which are indeed by far the commonest. It is in these that *Frerichs* was able to establish the fact that the cancer-tissue invaded the neighbouring lobules from the portal canals. The numerous injections which he made convinced him moreover that this growth occurred, so to speak, under the auspices of the hepatic artery, inasmuch as the cancer-nodules could only be injected from the trunk of this vessel, which was invariably much dilated, while the branches of the portal vein were compressed, and impervious to the injecting fluid. His fig. iv. (plate vii. second Fasciculus of Atlas) is highly instructive; we see the lobules adjoining a cancer-nodule actually melting into the growth. This figure, whose accuracy is indisputable, gives us the impression of a transubstantiation of the hepatic parenchyma, of the secreting elements themselves, and speaks a language far more distinct than all the arguments based upon inadequate observation.

Finally, the direct conversion of the liver-cells is also supported by the high degree of vascularity exhibited by all the softer varieties of hepatic cancer. The stroma of all the smaller nodules consists exclusively of wide and thin-walled capillaries. At a later period, an independent growth of the stroma by spindle-cells and connective tissue is superadded (*see* § 155); the trabeculæ become thicker, but the main ones always contain a blood-vessel of considerable size, which I regard as the representative of a pre-existing hepatic capillary.

§ 532. I think I have now brought the reader as far as the point where the threads of our investigation are broken off. It is as yet impossible to pronounce decisively concerning the origin and growth of cancerous tumours of the liver. But no such uncertainty hangs over their retrograde metamorphosis; this, in by far the majority of cases, sets out from a fatty degeneration of the oldest and most central cells of each nodule. We can measure the progress of this change even with the unaided eye, by the extent of a yellowish-brown or yellowish-white discoloration, and convince ourselves that the discoloured parts are especially soft, pulpy and diffluent. The fatty *débris* are capable of being absorbed. But absorption occurs only when the nodule is superficial, when one side of it—that towards the peritoneum—can sink in; it is impossible when the nodule is more deeply situated, and surrounded on all sides by a stratum of uniform thickness and rigidity (*Geschwulstwand*). Here, therefore, "cancerous abscesses" are formed, while in the superficial nodules we can observe the phenomena of umbilication. The umbilicus of a cancer-nodule is the saucer-shaped depression which forms over its collapsed centre. If we cut through it vertically, we come upon the so-called "cicatrix," *i.e.* the residue of the cancer-structure left after the removal of the cancer-cells, *sc.* the stroma and the obliterated vessels, together with the few which are still pervious; all these structures combining to form a solid cicatricial tissue, which sends ray-like prolongations on all sides into the stroma of the still florid portion of the tumour.

VIII.—MORBID ANATOMY OF THE KIDNEYS.

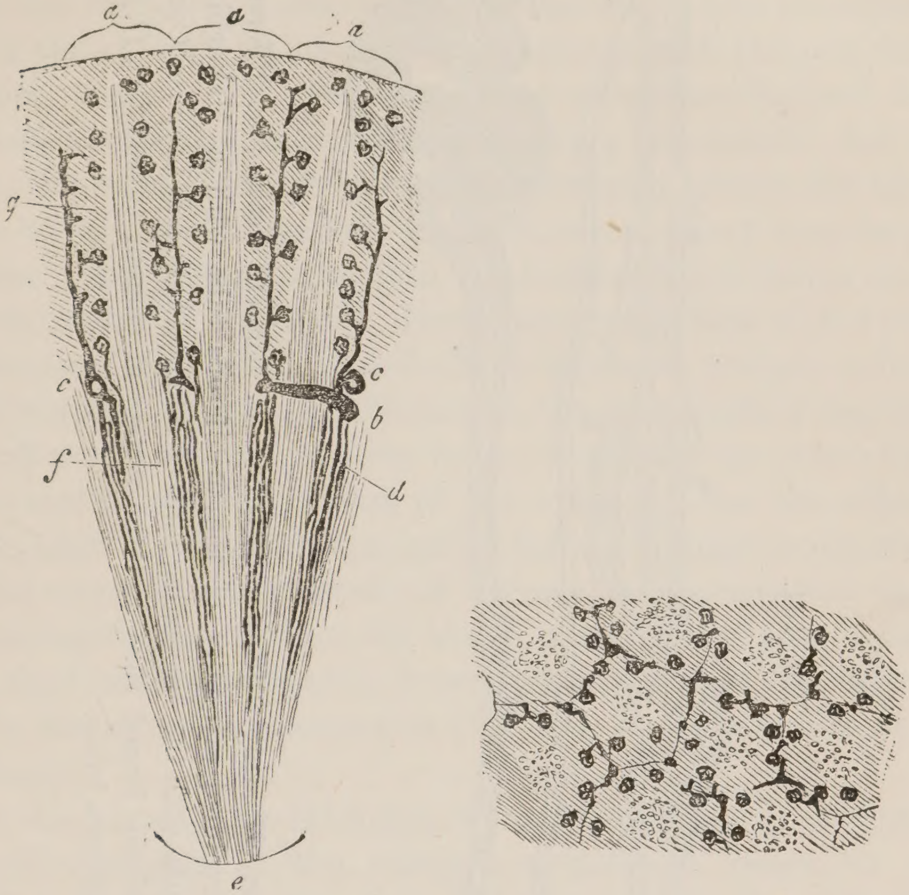
§ 533. It has been rightly suggested that one object of the study of pathological histology should be to acquire the power of estimating with the unaided eye (at least to some extent) whatever alterations may have occurred in the tissues. This object is better attained in the case of the kidneys than in that of any other organ. For this purpose the substance of the kidney must be divided into certain anatomical regions, within which the morbid processes either begin, or produce aggregates of structural change whose appearance is in the main characteristic. First, we have the primary distinction between the medullary and cortical substance, indicated by the course of the main divisions of the renal artery and vein on the one hand, by the restriction of convoluted tubes and Malpighian bodies to the renal cortex on the other. Further, we must distinguish in the CORTICAL SUBSTANCE—

1. The region of the Malpighian bodies and convoluted uriniferous tubes (fig. 153, *g*). This embraces four-fifths of the entire cortex. Inasmuch as the Malpighian capsules are the terminal dilatations and the convoluted tubes the terminal segments of the tubuli uriniferi, the region in question must necessarily correspond to the most important part of the secreting parenchyma. Moreover, it contains all the minute arteries and veins of the cortex, all the *retia mirabilia* with their respective afferent and efferent vessels, and the venous half of the capillary system.

2. The region of the straight uriniferous tubes. It would be more correct to use the word "regions" in the plural number, inasmuch as the area in question is broken up into as many subdivisions as the kidney possesses lobules. The medullary part of each lobule (fig. 153, *a a*) consists exclusively of straight tubes of two different kinds; first, of those relatively wide drains which open at the apex of the papilla (figs. 153, *e*, 154, *f*); secondly, of those extremely narrow looped tubes which communicate at one end with a convoluted tube, while opening at the

other into one of the efferent drains, obliquely from below upwards (fig. 154, *c*, *d*, *e*). The thickness of the bundle of tubes when cut across at any point, depends upon the number of these loops. The looped tubes in connexion with the Malpighian bodies of the extreme periphery of the cortex, barely dip into the medullary layer; those glomeruli which are most central in position, which therefore lie close upon the cortico-medullary boundary, send *their* loops nearly as far as the papilla;

FIG. 153.



Semi-diagrammatic representation of the structure of the kidney in vertical section; also in horizontal section through the cortex. *a a a.* The bases of the renal lobules, which exhibit a polygonal form in sections parallel to the surface of the kidney; *b.* A main branch of the renal artery, situated at the cortico-medullary junction, and giving off the *Arteriolæ ascendentes* with their Malpighian tufts to the cortex; *c.* Renal veins which receive the interfascicular vessels—the latter form stellate figures in the horizontal section; *d. Vasa recta;* *e.* Surface of the papilla; *f.* Fasciculi of straight uriniferous tubes which radiate into the connective substance as pyramids of Ferrein.

FIG. 154.

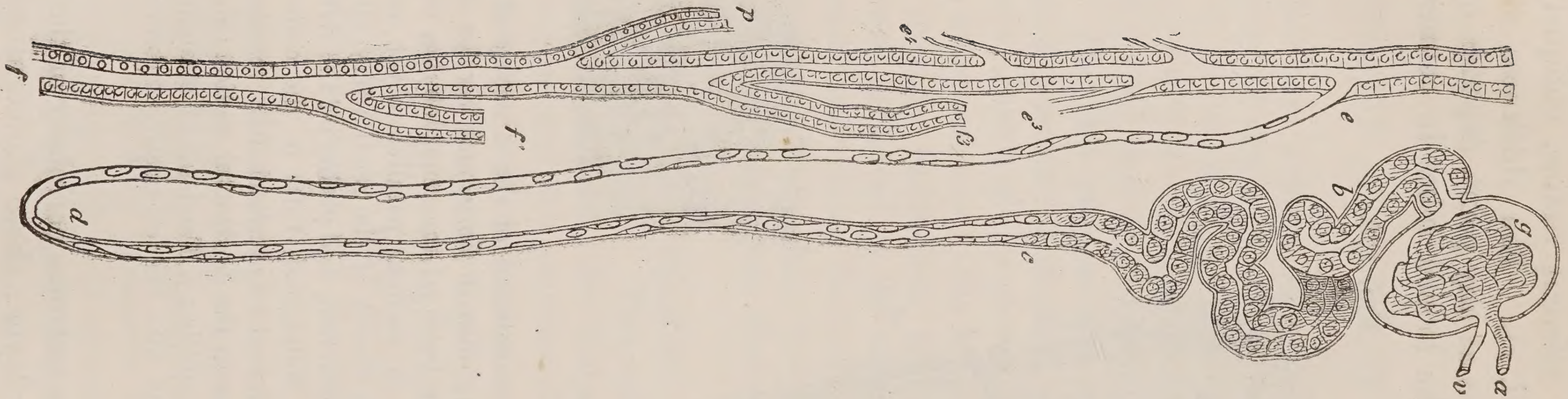


Diagram of the course and divisions of a single uriniferous tube. *a.* Afferent vessel; *v.* Efferent vessel of a Malpighian tuft (*g*); *b.* Convoluted extremity of the uriniferous tube with a Malpighian capsule; *c.* Junction of the convoluted tube with the descending limb of a looped tube; *d.* Loop; *e.* Communication between the ascending limb of the looped tube and the system of efferent tubes (f, f^1, f^2, f^3); e^2, e^3, e^4. Orifices of other ascending uriniferous tubes.

those again which are intermediate between the two extremes, send their loops down to a variable distance between the papilla and the cortico-medullary border, a distance proportionate to their own position. Hence it is, that at the cortico-medullary junction the ascending and descending limbs of *all* the looped tubuli are included in one transverse section, while towards the papilla those loops which are in connexion with the peripheric capsules, towards the periphery those which are derived from the central capsules, decrease progressively in number. Accordingly, the bundle of straight tubes belonging to any one lobule tapers at each end, if we take the cortico-medullary boundary as a centre. Its prolongation into the cortical layer forms one of the "pyramids of Ferrein." Now these "pyramids of Ferrein" are identical with what we call the "region of straight tubuli" in the cortical substance. Moreover, the fine-meshed capillary network which surrounds these tubes constitutes the arterial half of the entire capillary system of the kidney. For the efferent vessels, after leaving the Malpighian tufts, penetrate straightway into the centre of the pyramids of Ferrein, where they first break up into capillaries; so that the blood in each of the renal lobules flows from within outwards, notwithstanding that the afferent vessels, the *arteriolæ ascendentes* (fig. 153, *b*) are situated at its periphery.

In the MEDULLARY substance we must distinguish between:

3. The region of the straight uriniferous tubes, *i.e.* the medullary portion of the lobule (Cf. (2), and also fig. 153, *f*).

4. The region of the vasa recta. Small bundles of arteries and veins, starting from the cortico-medullary junction, are intercalated between the bundles of straight uriniferous tubes which correspond to the individual lobules (fig. 153, *d*). Inasmuch as these vessels are also straight, it is hard to distinguish them, when empty, from the adjoining tubuli uriniferi. Under such circumstances, the boundaries of the individual lobules cannot be distinguished with the unaided eye. It happens, however, that the vasa recta are nearly always full of blood, and thus serve as a most valuable guide to the immediate discrimination of adjacent lobules. The arteries are mostly derived from those glomeruli which lie nearest to the medullary border; they are much elongated vasa efferentia; a smaller number spring directly from the main divisions of the renal artery, which

run between the cortical and the medullary substance. The veins unite, close to the cortico-medullary junction, into short trunks which open directly into the main branches of the renal vein. The vasa recta are surrounded by a moderate amount of lax connective tissue, the terminal prolongations of that sheath of connective tissue which invests the renal vessels at their entrance into the hilus of the kidney.

We shall see hereafter to what extent these regional divisions of the kidney will aid us in the localisation of morbid changes without a microscope—in microscopy with the unaided eye.

1. Inflammation in General.

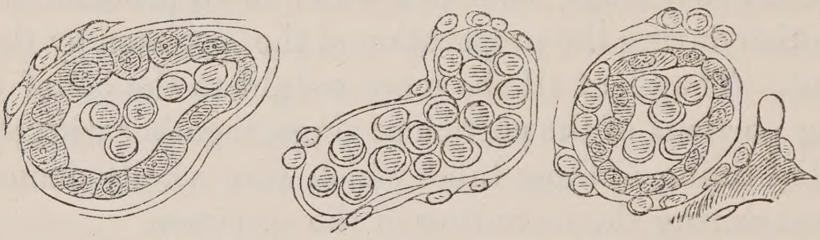
§ 534. The morbid anatomy of renal inflammation has been repeatedly investigated; and yet it is still the most incomplete chapter in the whole of our science. As we are far from being able to draw an anatomical picture of the stages of nephritis, we must regard the attempts made by *Rayer*, *Förster* and others, to draw sharp lines of distinction between simple, albuminous, parenchymatous, interstitial, and croupous nephritis, as wholly premature. This unreadiness and uncertainty in the domain of morbid anatomy is vividly reflected in the vacillating condition of clinical diagnosis; it is certainly not owing to respect for the memory of Dr. Bright that the very elastic term "Bright's disease" enjoys an undiminished popularity. In contrast with all this perplexity, the position of the pathological histologist may be regarded as relatively easy. We are free to view the alterations exhibited by the individual elements of structure, the uriniferous tubes, the connective tissue, the blood-vessels, as independent phenomena, and so at any rate to present the reader with an account of the constituent elements of the anatomical changes, without any admixture of hypothesis; we may then endeavour to construct the general anatomy of the principal diseases of the kidneys by combining those elementary data with one another.

a. *Changes in the Uriniferous Tubes.*

§ 535. Desquamative catarrh. If we squeeze the papillæ of a not very fresh kidney removed from the dead subject, we usually find that a small quantity of whitish, turbid urine oozes from the orifices of the ducts; its turbidity being due to the presence of epithelial cells, recognisable as shreds of the epithelial lining of the uriniferous tubes by their partially tubular connexion with one another. The constancy with which this phenomenon recurs must needs make it appear rather bold to infer the existence of a desquamative catarrh of the uriniferous tubes from an occasional discharge of these shreds in larger amount than usual; we are not justified in assuming, because the cells happen to separate more readily than usual after death, that the epithelium of the uriniferous tubes was loosely adherent to the *membrana propria* during life; on the contrary, we learn to be on our guard against drawing conclusions, under any circumstances, from the presence of denuded uriniferous tubes. While examining transverse sections of such seemingly denuded tubes from the renal papillæ, I have often come across remnants of the epithelial rings, remnants which in all probability escaped destruction during the preparation of the specimen by the merest accident. They lent all the more weight to the belief that the missing portions of the particular rings, together with the entire epithelial lining of those tubes which were wholly denuded, had been lost during the mounting of the specimen.

The reader might naturally be led to suppose from all this that I mean entirely to deny the existence of a desquamative catarrh of the uriniferous tubes; such, however, is not my purpose. I only wish to repudiate as evidence of this condition, a phenomenon on which reliance is very often placed, and which is nevertheless wholly untrustworthy. Desquamative catarrh of the tubuli uriniferi runs the following course: it begins with a granular cloudiness and desquamation of the existing epithelial lining; this is followed by a more abundant proliferation of young cells from the connective tissue surrounding the tubuli uriniferi, which leads to a more rapid renewal of the epithelial elements, and to the secretion of large numbers of isolated cell-forms of various ages. Here, indeed, we find ourselves face to face once more with the old question concerning the origin of the epithelial cells; and the existence of a *membrana propria* between the connective tissue and the epithelium is well adapted to rouse doubt and suspicion concerning the possibility of a renewal of the epithelial elements from the connective tissue. In the meantime our belief in the absolute homogeneity of the capillary walls has been rudely shaken by the recent discoveries of *Cohnheim* (*l.c.*); and the shock will undoubtedly be propagated to all homogeneous membranes whatsoever. I have already (§ 367) described the migration of young connective-tissue corpuscles through the basement-membrane of the mucous lining of the trachea in croup. I refer the reader, moreover, to the researches of *Iwanoff* on the migration of corneal elements through the anterior elastic lamina into the epithelium, in certain forms of pannus; again, the tubes of *Bellini* were subjected to investigation years ago by *Axel Key* with a view to this very question, and that not without some positive results. In conclusion, I refer the reader to the annexed drawings. Fig. 155 represents oblique and transverse sections through tubuli uriniferi in a state of catarrh. The middle one has lost the whole of its normal epithelium and contains in its stead only young and loosely-connected corpuscular elements. The other two show the epithelial lining more or less disjointed, with younger elements both above and below it. The corpuscular infiltration of the connective tissue is also indicated in the drawing. I have hitherto observed these alterations only in the system of tubes which open at the apices of the papillæ; tubes which may be distinguished from the looped tubes in the medullary layer by their greater width; from the convoluted tubes in the cortical substance by the brighter hue of their epithelium, as well as their greater width, though this latter difference is less marked than it is in the medullary layer.

Fig. 155.

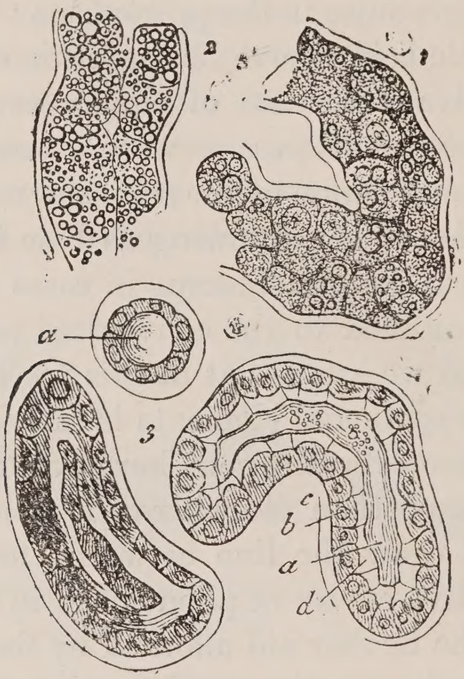


Transverse and oblique sections through uriniferous tubes in a state of catarrh. $\frac{1}{500}$.

§ 536. Cloudy swelling. Cloudy swelling of the secreting epithelium is among the most serious of the morbid changes to which the uriniferous tubes are liable. It is characterised by the appearance of a quantity of minute dark granules in the protoplasm, and a consequent increase in size of the individual elements. The demand for space on the part of the cells is met partly by a considerable dilatation of the entire tube, partly by the intrusion of the epithelial elements into its axial lumen. They accommodate themselves to the space thus furnished by alterations in their shape. Some form conical projections into the interior of the tube; others assume more of a spheroidal shape, making the outline of the affected tube bulge outwards at intervals (fig. 156, 1). The nuclei are masked by the dense cloud of minute granules in the protoplasm; but with the aid of carmine and acetic acid I have succeeded in demonstrating them even in very advanced cases of cloudy swelling. It seemed, moreover, as though the process were attended, oftener than is usually supposed, by fission of the cells and nuclei; yet I will not dogmatise on this subject, knowing as I do how very unreliable all our histological criteria become in cases of cloudy swelling. The change is confined to the convoluted portion of the uriniferous tubes; and we know that in this region a finely granular cloudiness of the epithelial elements is in some degree a normal phenomenon; moreover, the cells here possess more of a cubical or cylindrical shape than elsewhere; it would therefore be extremely hard to draw the line between cloudy swelling and a merely quantitative excess of phenomena in themselves normal, were it not for the farther aid afforded by the irregular arrangement of the altered epithelium, and the closure of the axial lumen by the swollen cells. The same is true of the fission of the cells and nuclei, which may also be observed in the healthy kidney. Our main reliance must unquestionably be placed on the general appearance of the tubes as seen in section; their marked dilatation, the varicosity of their outlines, and finally a not inconsiderable thickening and swelling of their *tunicæ propriæ,* which is never lacking in my experience, serve to render our recognition of the morbid state in question under the microscope, more certain than it could be from the mere examination of a single epithelial element.

The true nature of the chemical changes which occur in the protoplasm during cloudy swelling has not been hitherto ascertained. It is probably impregnated with some albuminoid substance, since the cloudiness, as we have already seen, may be dissipated by the addition of acetic acid. From the point of view of general pathology, cloudy swelling must be viewed as the result of an irritation of the cell by some morbid material in the blood. This may commonly be referred to some toxic or zymotic influence, such as phosphorus-poisoning, variola and the other acute exanthemata, typhus, puerperal and septic fevers; in all of these the poison is introduced into the system at a remote point, and conveyed to the kidneys, in common with other organs, by the blood.

FIG. 156.



1. Cloudy swelling and commencing fatty degeneration of the epithelia of the convoluted tubes; 2. Advanced stage of fatty degeneration; 3. Formation of fibrinous casts; *a.* Transverse section through a uriniferous tube with a gelatinous cast occupying its lumen; *b.* Epithelium; *c.* Tunica propria; *d.* Renewed production of colloid matter at the surface of the epithelial cells, detaching the previous layer. $\frac{1}{500}$.

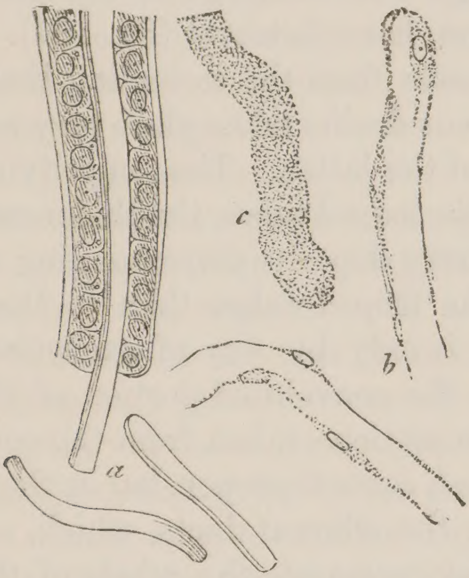
§ 537. FATTY DEGENERATION. The further destiny of epithelial cells affected with cloudy swelling is diverse. Minor degrees of the affection do not appear to offer any hindrance to a return of the cell to its normal state. If the granular matter be regarded as pabulum, left unassimilated in the cell in consequence of some disturbance of the nutritive exchanges, and precipitated in a solid form, the return of the cell to its normal state may be viewed as a resolution and elaboration of the solid matters. For obvious reasons we have no direct observations bearing on this point. On the other hand, there is the risk of fatty degeneration of the swollen epithelial elements. We find larger and darker granules appearing side by side with the minute albuminoid molecules; these granules are shown by their microchemical reactions (solubility in alcohol and ether) to be oil-globules. I have often been struck by the very great diversity in size of these oil-globules. Some are as minute as particles of dust, others so large as almost to suggest the idea of a fatty infiltration (fig. 156, 2), were it not that the development of granule-cells, and their subsequent disintegration into oily *débris*, afforded evidence only too certain of the destructive tendency of the process. The fatty metamorphosis, so long as the individual cells are still distinguishable, is associated with a still further distension of the uriniferous tubes; but this is only temporary, and speedily passes into the opposite condition, that of collapse. The fatty *débris* would appear to be partly expelled by the *vis a tergo* of the urine, partly absorbed; the uriniferous tubes being naturally left empty and relaxed. That the expulsion of the fatty *débris* is quite possible, is shown by the familiar occurrence of oil-globules and granule-cells in the urine. Some of these adhere, moreover, to the outer surface of the fibrinous casts which are simultaneously voided (*see* below), thus betraying their origin in the uriniferous tubes. The greater part of the fatty matter is, however, undoubtedly removed by absorption. *Beer* found the stroma of the kidneys, especially the stellate interstices for the connective-tissue corpuscles, loaded with oil-globules. His drawings agree so closely with the well-known appearance of the intestinal villi during the absorption of fatty matter, that no doubt on the subject is admissible. The *total* denudation of the uriniferous tubes seems to be far less conclusively proved. Indeed, the only evidence which can be adduced in its favour, is that of the total obliteration of the tubes amid the connective tissue of the wasted kidney—therefore only in the later stages of its contraction. But I have never seen a kidney whose cortical substance was made up, either wholly or in part, of collapsed and denuded uriniferous tubes. It seems likely, therefore, that the desquamation caused by the fatty metamorphosis which follows cloudy swelling is provisionally compensated by a proportionate aftergrowth and renewal, and that in this way a complete restitution of the epithelial lining of the convoluted tubes lies within the bounds of possibility. Clinical experience is also in favour of this view.

It is a very different thing indeed when the epithelium of a uriniferous tube which happens to have been strangled or cut off from its supply of nourishment by an interstitial development of connective tissue, and whose entire obliteration is merely a question of time, undergoes fatty degeneration. Such conditions are extraordinarily frequent in those kidneys in which nephritis, grown chronic, has half completed its work of destruction (*see* § 562). Here, however, the fatty degeneration is in nowise a result of antecedent cloudy swelling; it merely serves to show that the uriniferous tube is no longer supplied with an adequate amount of nutrient matter, in consequence of which the epithelial elements, which contain much protoplasm, and are therefore in want of an abundant supply of pabulum, fall a prey to necrobiosis. The minuter details, indeed, in this form of fatty degeneration, are the same as in the acute variety; but the cells do not all die at once; on the contrary, all stages of the process are found side by side, as might have been anticipated from the etiology of the disorder.

§ 538. FIBRINOUS CASTS. One of the most important signs of the existence of hyperæmic and inflammatory changes in the kidneys is afforded by the discovery of the so-called "fibrinous casts" in the urinary deposit. These are colourless, hyaline cylinders, which agree so exactly with the known dimensions of the uriniferous tubes, that their true nature, as casts of the straight tubuli, would hardly be doubtful even although they had not been demonstrated *in situ* (fig. 157). Another step brings us to the conclusion that these casts must have originated after the same fashion as the casts of the bronchioles in croupous pneumonia; following up this notion, we arrive at the theory of a croupous nephritis with a fibrinous exudation into the tubes. In aid of this view we have the highly plausible suggestion of *Traube*, that the rise of the blood-pressure in the medullary cones must needs lead to the filtration of progressively denser blood-constituents through the walls of the vessels; first of albumen, then of fibrin, lastly of corpuscles. This theory, owing to *Traube's* reputation as a worker in the field of renal pathology, is very generally accepted in medical circles. Even now, the only objection that can be brought against it is, that the so-called "fibrinous casts" are not believed by chemists to consist of true fibrin at all. This objection, however, does not in any way invalidate the main feature of *Traube's* doctrine, *sc.* that the degree of albuminuria is directly proportionate to the degree of congestion of the medullary substance of the kidneys.

It may be doubted whether the fibrinous casts can be produced at all without the active participation of the uriniferous tubes. I have long been in favour of the view that the epithelial cells with which the straight tubes are lined generate a colloid material in their protoplasm, which they then pour out into the interior of the tubes. The appearances in fig. 156, 3, seem to me to admit of only one interpretation, namely that the consolidation of a cylinder of fibrin, *a*, which occupies the axis of a tube, is followed by a renewed production of colloid matter, *d*, from the epithelial elements, *b*. Yet I must admit with *Klebs* that here, as elsewhere, the possibility of some simple exudation from the protoplasm of the epithelial cells, perhaps of post-mortem origin, perhaps due to the mode of preparation, cannot be excluded. The matter is not yet ripe for a decision ; and as it has been recently shown (*Heynsius*) that the blood-corpuscles

FIG. 157.



Fibrinous Casts. *a*. In the interior of a uriniferous tube ; *b*, *c*. In the urine, more or less richly coated with fatty molecules. $\frac{1}{500}$.

contain fibrin, we have to bear in mind the possibility that the fibrinous casts may be a product of the lixiviation of extravasated blood-corpuscles. Provisionally, we must content ourselves with the statement that a fluid substance of albuminous nature is poured into the uriniferous tubes, forming a cylindrical cast by its coagulation. Should there be any detached cells lying in the tube, as happens in catarrhal states, these will be fixed in the middle of the cast. Then the outlines of the cylinder grow sharper and more defined, and its forward movement —its expulsion—begins. This is effected by the *vis a tergo* of the urine, and meets with no hindrance, owing to the extremely flexible and slippery character of the cylinders, notwithstanding the manifold turnings and windings of the path along which some of them, at least, have to travel (fig. 154). In particular, the passage of the casts from the ascending limb of the looped canals into the efferent drains takes place very readily, owing to the greater calibre of the latter. The majority of the casts are actually formed in the looped tubes, the thickness of those which are met with in urinary deposits corresponding more commonly to the calibre of the looped tubes than to that of the wider efferent drains. It is only by way of exception that fibrinous casts are formed in the convoluted portion of the tubes; those casts which occur in sections taken from the cortical substance lying not in the *tubuli contorti* proper, but in the lacunar fissures of *Schweigger*, or in the efferent ducts, which, according to the observations of *Henle*, permeate the whole of the cortical substance uniformly, forming an independent system of canals, and which may therefore be met with among the convoluted tubes.

§ 539. AMYLOID INFILTRATION. I am convinced that fibrinous casts which have become impacted in the narrowest portions of the tubes, particularly in the bent part of the looped tubes, swell up in course of time and become glassy, exhibiting the microchemical reactions of amyloid matter, *e.g.* taking a brownish-red colour on the addition of iodine. This is the only way in which I can explain the fact, that in kidneys otherwise profoundly altered, though not lardaceous, amyloid cylinders are met with in the bent part of the looped tubes, blocking them to a considerable distance. These cylinders cannot be supposed to consist of altered epithelium (*see* below), for the epithelial layer may be seen in a state of excellent preservation between them and the basement-membrane of the tubes. Moreover, amyloid infiltration of the epithelial cells is only found in the extremest examples of the lardaceous kidney; so that in order to account for these isolated amyloid cylinders, we are compelled to take refuge in that localised production of amyloid substance from "coagulated albuminous matters retained *in situ*" which has been more fully discussed in § 50.

In the generalised form of waxy kidney (Cf. § 564) the uriniferous tubes are not, as a rule, the first to be involved. The chief deposit occurs in the transparent hyaline membranes, which swell up considerably, present a brilliant lustre in transverse sections viewed by transmitted light, and yield the usual reactions with iodine. The epithelial cells resist the change for a much longer period. When they finally succumb, they swell, their outlines become indistinct, they blend with one another, and the complete obliteration of the axial lumen of the tube coincides with the formation of an amyloid cylinder which still retains indications of its original corpuscular composition in the wavy bulging of its outlines (*Key*). Amyloid infiltration of the uriniferous tubes is found together with a similar alteration of the vessels, particularly of the vasa recta, chiefly in the papillæ of the kidney; from this point, however, it radiates even into the pyramids of Ferrein. I have never observed it in the convoluted tubes; though I do not doubt the possibility of its occurrence in them. But it must always be very hard to distinguish the diseased tubes from the vessels which are similarly affected.

§ 540. Cystoid degeneration of the uriniferous tubes is due either to plugging or obliteration. It takes place according to the general laws which regulate the development of retention-cysts, presenting however some very essential local modifications.

A very common obstacle to the escape of urine is offered by the amyloid cylinders impacted in the looped tubes, as described in the foregoing section. In their immediate neighbourhood, minute cysts as big as a pea and under are often found scattered through the medullary substance of the kidney; these cysts are sometimes few in number; sometimes so numerous as to touch one another, forming beaded rows, &c. (fig. 160, *f*).

If we divide the entire length of the medullary substance into four equal parts, the second quarter, counting from the papilla, is unquestionably the favourite seat of cysts of this description; from this point they decrease progressively in number as we approach the cortical layer; in the immediate neighbourhood of the papillæ, they are as invariably absent as they are at the cortico-medullary boundary, or at that of the pyramids of Ferrein. As regards the details of their development, it would seem as though a gelatinous softening of the plug itself played an important part in the earliest stages of the dilatation. Until they reach the size of a pin's head, the cysts do not contain a clear or urinous fluid, but a substance which readily coagulates on the addition of alcohol, chromic acid, &c., exhibiting a concentric lamination in transverse sections; it takes up carmine readily, and retains it very firmly; it is, in short, a semi-solid, gelatinous modification of albumen. In the individual cysts of this size, neither epithelium nor basement membrane can be detected; and they pass so uninterruptedly into the surrounding tissues, that one cannot but adopt the notion of a process of centrifugal softening. The latter, indeed, is necessarily confined within very narrow limits; the larger cysts are sharply marked off by a capsule of connective tissue, their contents becoming structureless, transparent and watery. These more elaborate investigations must not be allowed to shake our faith in the views put forth by *Beckmann*, and accepted by *Virchow*, to the effect that the smaller, multiple cysts of the medullary substance, which occur in cases of interstitial nephritis, are really due to retention.

§ 541. *Cysts due to strangulation of the tubes* are found in the cortex of those kidneys in which an inflammatory overgrowth of the connective tissue has occurred chiefly about the larger renal vessels at the cortico-medullary junction. These cysts may either be solitary, or so numerous as to occupy the entire cortex, leaving only a small residue of relatively healthy parenchyma. In the latter event (that of cystoid degeneration) we have our best chance of tracing the development of the cysts through all its stages. *Virchow* has recently warned us, very justly, against the notion that each cyst originates from a single uriniferous tube. On the contrary, the first rudiment of a cyst is composed of a round circumscribed spot, about the size of a hemp-seed, in the region of the convoluted tubes; within this area all the tubes are markedly dilated and their walls fused together; so that in the aggregate, they present the appearance of a single cyst traversed by thin septa. These septa next undergo atrophy where they are thinnest; the dilated tubes communicate with one another, and finally coalesce to form a single cyst of larger dimensions. The remains of the septa shrink back like a torn cobweb upon the walls of the cyst, where they may be found even in cysts of considerable size. The cysts originally contain a urinous fluid; even in specimens of large size I have detected urea in considerable quantity (by evaporating the fluid with several times its volume of rectified spirit, extracting the residue with absolute alcohol and ether, and treating the extract with nitric acid); this circumstance being especially noteworthy in the face of the wholly negative results arrived at by *Beckmann*. Blood is not seldom found in these cysts, giving them a brownish or ochrey tinge; albumen may also be present, when it coagulates on boiling.

§ 542. *Congenital cysts* of the kidney originate in precisely the same way as the cysts resulting from interstitial nephritis. A child is born; it dies during birth, or after making a few vain attempts to breathe. The cause of its death is found to be a cystoid degeneration of both kidneys, in consequence of which each of these organs is represented by a tumour some two* inches in length and an inch and a half in thickness. The diaphragm is pushed upwards; the lower half of the thorax is funnel-shaped and contains the liver, no room being left for the lungs to expand. On investigating the mode of origin of these cysts we find that they invariably start from the Malpighian bodies. Side by side with some which are perfectly normal, we find others in which the capsule has retreated from the vascular tufts, leaving a gaping crescentic interval of variable width. The greater the size of this interval, the more nearly will the glomerulus resemble a mere projection from the wall of the cyst; it can still be found, however, even in cysts as big as a pea. The uriniferous tubes may also undergo cystoid degeneration in their continuity; but such cysts are always formed by the dilatation of a single tube; they never originate or increase in size by the coalescence of several tubes. On the contrary, the larger the cyst, the thicker do the intertubular septa appear to become. Moreover, these septa are abundantly furnished with lymphatic spaces, which may be admirably injected from the perivascular connective tissue of the hilus. The development of the vascular system is excessively meagre; the calibre of the renal artery, where it leaves the aorta, is so narrow as barely to admit a pin; the vein is relatively wider.

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* *Sic.*—Tr.

The proximate cause of this congenital cystoid degeneration is said by *Virchow* to be the intercalation of a mass of connective tissue between the calyces and the papillæ of the kidney ; I agree with his view, without however allowing myself to express any definite opinion concerning the nature of this connective tissue. If it be true that the tubuli uriniferi and the calyces grow towards each other during the development of the organ, then it would seem as though, in these cases, their junction were not accomplished.

b. *Alterations in the Connective Tissue.*

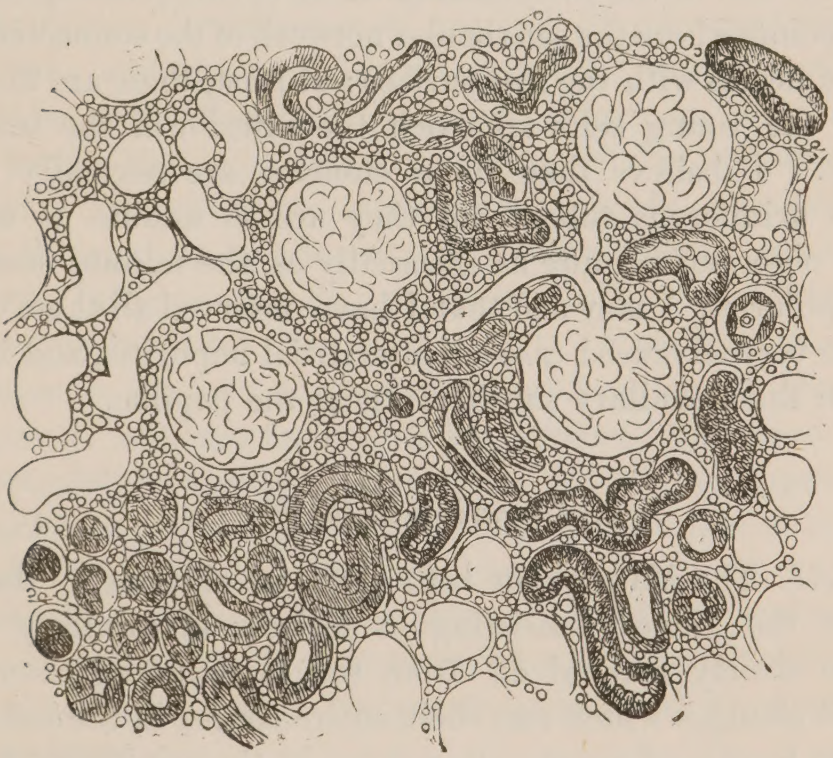
§ 543. Before proceeding to inquire into those morbid changes which set out from the connective tissue of the kidney, we must say a few words concerning the nature and distribution of this substance in the normal state. On teazing out a bit of a recent kidney on a slide, and placing it under the microscope, we might reasonably doubt the very existence of any connective tissue. The eye can detect nothing but seemingly naked uriniferous tubes and blood-vessels. A very careful inspection of the individual tubes is requisite to enable us to see minute shreds of a substance resembling a coagulum, and often finely granular, attached to them here and there; this it is which must be regarded as connective substance. On the other hand, sections taken from various parts of the organ which have been soaked for a little while in a solution of carmine, and then treated with acetic acid, yield far more satisfactory results. They serve to convince us most completely, that both in the medullary and the cortical substance, the uriniferous tubes on the one hand, the blood-vessels on the other, are held together by an organised cement which is none other than the connective substance of which we are in search. A basis-substance, which clears up on the addition of acetic acid, contains in spindle-shaped and stellate interstices of corresponding size, the familiar corpuscles of connective tissue. As a general rule, we find one corpuscle in each of the triangular lacunæ which are left between the circular outlines of the ducts when these are cut across. This arrangement holds in the region of the convoluted tubes; towards the papillæ the width of the triangular lacunæ increases, and the number of the corpuscles becomes greater; the tip of the papilla being formed by a plate of dense connective tissue, very like a sieve, owing to the numerous foramina for the transmission of the efferent canals. Larger accumulations of connective tissue, whose basis-substance may even present incipient fibrillation, are met with, as has been already stated, round the greater vessels and the vasa recta.

§ 544. A formative irritation of the connective tissue of the kidneys, either primary or secondary, diffuse or circumscribed, is more or less decidedly associated with all inflammatory conditions of the organ. Reserving all minutiæ concerning the manifold varieties of this morbid state for our future description of "the inflamed kidney," we shall content ourselves for the present with tracing the sequence of the textural changes. It may follow different directions. *Beer* distinguishes between a simple and a corpuscular overgrowth (hyperplasia), understanding by the former a gradual tumefaction of the interstitial tissue, during which its structure exhibits only one observable modification, *sc.* that the corpuscular elements tend to become enlarged; their number remains unaltered; as for the intercellular substance, it seems to increase in amount in proportion to the enlargement of the connective-tissue corpuscles. The remaining changes are of a subordinate character; it would seem, namely, that in proportion as the intercellular substance accumulates in greater quantity, it takes on more of a "fibrillar" character. On the whole, the entire series of changes admits of being regarded as an overgrowth of the connective tissue, in the narrowest sense of the word—as a uniform increase of all its textural elements alike. It is not so much a result of inflammatory changes proper, as of prolonged venous congestion; here, however, confusion is not unlikely to arise, inasmuch as the active congestion which ushers in inflammatory changes, is likewise associated with a tumefaction of the basis-substance and of the connective-tissue corpuscles, due to a thorough saturation with serous fluid.

§ 545. Of greater moment for the pathology of nephritis is the process described by *Beer* under the name of "corpuscular" overgrowth (hyperplasia); it is synonymous with the "recent inflammatory" or "plastic" infiltration of the connective tissue, which I have so often described, consisting in the accumulation of cells devoid of membranes, equivalent to colourless blood-corpuscles, embryonic cells, &c., wherever there is room for them to accumulate. It is hard to ascertain the source of these cells. Not that we lack plausible hypotheses to account for their origin; on the contrary, we have too many such. We must therefore leave it undecided to what extent they may be colourless corpuscles which have emigrated from the vessels, or the newly-formed progeny of the connective-tissue corpuscles of the kidney. Microscopic examination of transverse sections shows us that the intertubular septa of connective tissue are often three times as broad and thick as they usually are. Where the young cells are somewhat sparse, they lie in ordered rows; where closely packed, they form continuous masses. A double or triple zone of such cells usually environs each Malpighian capsule; a pregnant fact for the due understanding of the next stage in the degenerative process (fig. 158).

§ 546. It is only in certain very definite cases, that the corpuscular proliferation transgresses the limits between embryonic tissue and pus. The pus invariably collects in the form of abscesses, whose shape and size depend on the cause of the suppuration. The embryonal condition of the interstitial connective tissue, such as we have hitherto observed it, is commonly followed by a reduction in volume, which we cannot but compare with the shrinking of a cicatrix. There are legitimate objections to this view, however. What really does occur, and can everywhere be demonstrated with ease, is not an alteration in the quality of the connective tissue, but a recession and obliteration of those other textural elements of the kidney which are embedded in the connective tissue, *sc.* of the uriniferous tubes, blood-vessels, and Malpighian tufts. A gradual shrinking, associated either with a fatty metamorphosis, or with a condensation of their substance by compression, may be observed in all these structures. The Malpighian bodies wither, so that we find in their stead minute spheroidal bodies of peculiarly tough and dense consistency, containing not a trace of blood. These bodies are made up of a non-laminated nucleus, corresponding to the compressed vascular tuft, and a thick, concentrically-laminated capsule of connective tissue, which invests this nucleus. In the face of these appearances we can hardly avoid supposing that an actual strangulation of the *rete mirabile* has here taken place, due simply to the spontaneous contraction of connective tissue which has become cicatricial (fig. 160, *d*). This, however, is the only fact which lends colour to the theory of a *qualitative* alteration in the young connective tissue. Indeed, simple compression would suffice to explain the phenomena, since the mere obliteration of the uriniferous tubes, *e.g.*, would make the most extreme diminution of the entire kidney intelligible. Even in extreme cases of contracted kidney, no appearance of delicate striæ, or of fibrillation, can ever be detected in the encroaching connective tissue; and as for the corpuscles (whose number invariably undergoes a great reduction during the development of cicatrices), I have never yet been able to convince myself of any noteworthy diminution in their number.

FIG. 158.



Corpuscular overgrowth of the interstitial connective tissue. $\frac{1}{300}$.

§ 547. Very interesting, and bearing closely upon the histological significance of "homogeneous membranes," is the behaviour of the basement-membranes of the uriniferous tubes under these conditions. It is quite certain that they constitute an independent element in the structure of the healthy kidney, an element which is more intimately connected with the epithelial lining of the uriniferous tubes, than with the surrounding connective tissue. When the latter undergoes corpuscular overgrowth, however, this relation is inverted, and the true nature of the basement-membranes is made manifest. They may be said to make common cause with the young connective tissue round them; they blend with it, and speedily become no more than a sharp line of demarcation, separating the connective tissue from the lumen and the epithelium of the uriniferous tubes. At the same time, little depressions often make their appearance in them, irregularities in the roundness of their outline, corresponding to those points where the canalicular network of the connective tissue communicates with the free surface; at least, these are the points where the young cells approach the interior of the tube most closely. I believe that these stomata are normally present in the uriniferous tubes; but they are so minute as to elude direct observation quite as effectually as the minute stomata in the capillaries. I may add that I have observed all these changes only in very advanced cases of interstitial nephritis, and hitherto only in the medullary substance, near the papillæ.

c. *Alterations in the Vessels.*

§ 548. The Malpighian tufts form an element in the structure of the kidney consisting so entirely of capillary vessels, and so clearly marked off from the surrounding tissues, that morbid changes which run their entire course in the tufts are as little to be classed among alterations in the uriniferous tubes, as among those in the connective tissue. *Klebs* (Handbuch der pathol. Anatomie IV. 644) has described an inflammatory overgrowth of that small modicum of connective tissue which holds the vascular loops of the glomeruli together, and which was first noticed in the healthy kidney by *Axel Key*. In glomerulonephritis, we find the Malpighian tufts deprived of blood; on the other hand, "the capsule is quite filled with small, somewhat angular nuclei, which lie embedded in a finely granular substance." A more minute investigation shows conclusively that these corpuscular aggregates are, for the most part, infiltrated between the capillary vessels, which they have accordingly compressed. Inasmuch as glomerulo-nephritis has hitherto been observed only in scarlet fever, it may at any rate be made to furnish an adequate explanation of the sudden and often absolute suppression of urine, the acute transudations, and the rapidly fatal uræmia (sometimes causing death in from twelve to twenty-four hours) which occur in the course of this disease.

An exhaustive summary of the anatomical factors of renal inflammation must embrace some notice of a textural change in the vessels, which, though not in any way connected with inflammation as such, stands nevertheless in an intimate causal relation towards it—I mean amyloid infiltration of the walls of the vessels. In § 48 *et seqq.* the prominent place taken by the vascular system in reference to amyloid disease was very fully considered; and the example selected on that occasion was a Malpighian tuft. Indeed it is almost exclusively in the Malpighian bodies that the first beginnings of the disease can be observed. The afferent vessels and *arteriolæ ascendentes* are usually the next to be affected; while the efferent vessels and vasa recta, lying as they do on the distal side of the *retia mirabilia,* are not involved till a later period. A striking feature of the process is the lack of uniformity with which the glomeruli are affected; not only are several loops found intact in an otherwise completely diseased glomerulus, but we very commonly find perfectly normal glomeruli lying side by side with others which are in a state of advanced degeneration; and we cannot but infer, that this prolonged immunity must depend in some way on the collateral fluxion caused by the partial obliteration of the blood-path, though the precise method of its operation is still a mystery.

When the degeneration of the cortical substance has reached this point, the change usually extends to the medullary layer; but here, as has already been stated, it is not the blood-vessels, but the *tunicæ propriæ* of the uriniferous tubes, which are the first to be involved. If, now, we take a narrow disk from the transverse section of the organ, and after washing it, put it for a short while into a dilute watery solution of iodine, we can detect, even with the naked eye, a number of mahogany-coloured dots and lines in the cortical substance, which correspond to the glomeruli and the degenerated arterioles, while the medullary substance presents a crown of finely-radiating lines of the same colour, which are most closely aggregated just above the papilla, becoming more and more scattered as we approach the cortico-medullary junction.

In very extreme cases of amyloid kidney, everything endowed with a homogeneous membrane is found infiltrated—vessels and uriniferous tubes alike; the connective tissue alone, together with most of the epithelial cells, remaining free.

2. THE INDIVIDUAL FORMS OF NEPHRITIS.

§ 549. Let us endeavour, with the aid of the histological knowledge we have acquired, to construct a series of well-marked or frequently-recurring combinations, the individual members of which are usually grouped together under the common head of "inflamed kidney." The frequent union of undoubtedly inflammatory with non-inflammatory states (*e.g.* with conditions of degeneration or of simple overgrowth), obliges us to include some account of the cyanotic and the purely amyloid kidneys, though these may not appear strictly to belong to the group.

a. *Hyperæmia—Cyanotic induration—Nephritis due to passive congestion.*

§ 550. In the kidney, as in other organs, we must distinguish between active and passive congestion, regarding the former as the introductory stage of inflammation, the latter as the result of some mechanical hindrance to the escape of blood. To the morbid anatomist, however, the presence of either of these forms of congestion is announced by one and the same phenomenon, which varies, at most, in the degree of its intensity; *sc.* an accumulation of blood in the venous system of the kidney, extending to a variable distance into the arterial half of the capillary tract; the arteries themselves, as far as the glomeruli, always containing but little blood. The glomerulus itself takes up a position of its own in this respect; for it can only be made to part with a certain quantity of its contained blood, by a direct diminution of its capacity in consequence of pressure from without; apart from this, it invariably presents itself as a red dot on the cut surface of the organ.

§ 551. The most intense degree of renal hyperæmia is characterised by a very marked intumescence of the entire organ, which may increase in bulk by about one-third. The capsule peels off very readily, owing to the serous saturation of the parenchyma. The latter is of a bluish-red hue, moist and smooth; the *stellulæ Verheynii* are well marked, and may be traced even with the naked eye into their finer ramifications, the inter-fascicular veins. In transverse sections, the main bulk of the blood is found to have stagnated in the region of the convoluted tubes; the glomeruli are not always exceptionally gorged; and this may possibly furnish us with a means of discriminating between active and passive congestion. The medullary substance, particularly in the region of the vasa recta, presents a number of deep-red radiating striæ, obviously due to engorgement of the veins.

In minor degrees of congestion, the redness and swelling in the region of the convoluted tubes are wanting; on the other hand, the distension of the stellate veins, of the glomeruli and the vasa recta, is less only in degree; it is never absent, as I have already said, even in the healthy kidney, and cannot of course be regarded as a phenomenon intrinsically morbid.

§ 552. Should the renal congestion be a chronic state due to venous stasis, further alterations ensue; foremost among these is that simple overgrowth of the interstitial connective tissue which has been more fully described in a previous section (§ 544). This occurs quite uniformly throughout all the regions of the kidney, differing thereby very essentially from the corpuscular form of overgrowth; the organ as a whole increasing uniformly in weight, bulk and consistency. Most striking is the increased toughness of its tissue; this is the more likely to lead to confusion with "inflammatory induration" of the kidney, as a proliferation of connective tissue actually does occur in the present case. Accordingly, some authors have set up a category of "nephritis from passive congestion," although the development of the connective tissue is merely a result of improved nutrition, and is therefore of a distinctly homologous character. Neither the blood-vessels nor the uriniferous tubes are in any way affected by this connective tissue; the urine, however, is usually found to contain albumen from time to time; this indicates that the congestion undergoes periodical exacerbations.

The most extreme degree of renal congestion I have ever seen, occurred in recent cases of Asiatic cholera. In this disorder it ushers in a parenchymatous inflammation, and we may fairly assume that it performs a like office for every form of parenchymatous and catarrhal nephritis. Congestion from venous stasis (passive congestion), and the cyanotic induration which follows it, are always due to heart disease, particularly to contraction and insufficiency of the mitral valve.

b. *Acute parenchymatous Nephritis—Nephritis Albuminosa.*

§ 553. MILDER FORM. The kidney is moderately, but distinctly, enlarged; its consistency hardly, if at all, altered; the capsule peels off readily; the stellate veins are distinctly marked upon its surface; the accumulation of blood in the veins and the venous half of the capillary network, throws the lobular divisions of the organ into marked relief. Transverse sections show the same appearances. The region of the convoluted tubes is yellowish-grey, soft and doughy; it is slightly raised above the level of the cut surface. The Malpighian bodies are visible in it as red dots. A moderate degree of cloudy swelling of the epithelial elements (§ 536) in the convoluted tubes, is associated with the hyperæmia, and complicates its manifestations. All else is still quite normal, especially the medullary substance.

§ 554. MORE INTENSE FORM. The kidney is enlarged to twice its normal size. The capsule is thinner than usual and peels off readily. The denuded surface exhibits only the larger stellate veins, which contrast vividly with the yellowish-white parenchyma. The most striking peculiarity of the parenchyma, next to its colour, is its soft and doughy consistency. On making a section through the organ, however, we see at once that both of these qualities are exclusively confined to that portion of the kidney which corresponds to the convoluted tubes. This portion, indeed, is coextensive with the cortical layer, with the exception of the little pyramids of Ferrein, so that the customary description of acute Bright's disease as a yellowish-white, doughy intumescence of the cortex, with a congested but not otherwise altered state of the medullary substance, accords very fairly with "acute parenchymatous nephritis." The Malpighian tufts can no longer be distinguished with the naked eye; in common with all the blood-vessels in the region of the convoluted tubes they are found to be quite empty after death. Without doubt, an intensified degree of cloudy swelling of the epithelial elements (§ 536) in the convoluted tubes, and the consequent increase in volume of the latter structures, have primarily resulted in a swelling of the organ as a whole; next, inasmuch as there are limits to the extensibility of the renal capsule, they have led to compression of the blood-vessels in the interior of the altered parenchyma; so that the cortical substance may be described as actually anæmic. The blood seems thus to be diverted into the veins and capillaries of the medullary substance. Allusion has already been made to the striking and highly characteristic circumstance, that the medullary substance of the inflamed kidney appears to be congested in proportion to the degree of anæmia of its cortex. Meanwhile we must be cautious in inferring from the presence of this singular, and certainly very important, anomaly in the distribution of the blood after death, that the blood is similarly distributed during life. It is only when the vessels have undergone amyloid degeneration, that we are unable to inject the organ from the renal artery. Now amyloid degeneration is an excessively rare complication of parenchymatous nephritis. Should the vessels be healthy, as they usually are, every capillary in the cortical substance may be filled. It is true that we remark an increased but yet elastic resistance to the flow of the injection—a resistance which must certainly have existed during life, but which is not powerful enough to have absolutely prevented the access of the blood. Indeed the cessation of the *vis a tergo* after death must have added to the power of this elastic reaction, and so enabled it wholly to expel the blood contained in the cortex, and to drive it into the veins and the medullary substance; I repeat therefore, that however extreme we may find this anomalous distribution of the blood after death, we are not entitled to assume that it existed during life.

This form of nephritis is clinically associated with scanty secretion of urine of a dark colour, highly albuminous, and abundantly furnished with casts; it may or may not contain blood; it never contains pus. The disorder sets in acutely with severe pain, and may, owing to the arrested function of all the epithelial cells in the convoluted tubes—a phenomenon which is nearly identical with suppression of urine—lead to a speedily fatal end. Death occurs with symptoms of uræmia and dropsy. Acute parenchymatous nephritis is always a result of toxæmia, in the broadest sense of the word. It may be excited by the acute exanthemata, particularly small-pox and scarlet fever, by phosphorus, typhus, cholera, pyæmia and puerperal processes.

§ 555. Recovery from parenchymatous nephritis takes place, in the milder forms, by a resolution of the solid albuminates which occupy the cells of the convoluted tubes; in its more intense forms, a process of fatty metamorphosis, whose beginnings we usually see in cases which prove fatal, occasions a total disintegration of the epithelial cells. The loss is covered by a development of cells *de novo;* the connective tissue must unquestionably be regarded as the agent in this process of repair (Cf. § 537).

c. Interstitial Nephritis.

§ 556.—1. CIRCUMSCRIBED SUPPURATIVE FORM. *a. Renal Abscesses in Pyelitis.* The kidney is markedly enlarged. Its capsule and the adipose tissue in which it lies, are congested and œdematous. The former does not always admit of being stripped off without loss of substance; very commonly, small shreds of parenchyma destroyed by suppuration remain attached to it—shreds which previously covered in one of the abscesses to which allusion will presently be made. The remainder also of the inner surface of the capsule is not as smooth as usual, but rough and velvety. At various points on the denuded surface of the organ, we notice slight straw-coloured elevations, which attentive examination forthwith proves to be purulent deposits. They are of an average size of half a pin's head; either solitary or arranged in groups of from three to six. If we proceed to examine the boundaries of the great Malpighian pyramids, which are indicated by shallow depressions of the surface, we commonly find that all, or at least the great majority of the abscesses, are situated in the base of *one* of these pyramids, while others are absolutely free.

Each abscess is surrounded by an intensely red areola. It has been supposed, on the ground of their dimensions, that each abscess corresponds more or less to one expanded lobule; this, however, is incorrect; the centre of the abscess corresponds in position to an inter-fascicular vein, where it emerges from below, as will be seen on further investigation. The remainder of the surface is moderately congested; this congestion extends uniformly over the entire surface of section as well; yet everything seems clouded with a greyish veil—the optical effect of a moderate but uniform corpuscular overgrowth of the connective tissue (§ 546). The cut surface (by which I invariably mean the principal section, which, carried from the greatest circumference of the organ to its hilus, divides it into two equal halves) also furnishes data for the determination of the seat and distribution of the abscesses. These appear in section as long streaks of yellow pus which correspond, in the medullary substance, to the tissue surrounding the vasa recta; in the cortex, to the inter-fascicular vessels, or rather to the bands of connective tissue which accompany those vessels. They are always most densely aggregated in the medullary substance, most of the abscesses in the cortical layer appearing as outward extensions of the suppurative process from the medulla; even the dots of pus which are seen on the surface of the organ prove, upon occasion, to be merely the outer ends of abscesses which extend very nearly as far as the papilla. The uriniferous tubes of the medullary substance are in a state of desquamative catarrh (§ 535).

The calyces and pelvis are always dilated; their lining membrane in a state of suppurative catarrh (*Pyelitis*), in patches diphtheritic; they contain a certain amount of very fetid ammoniacal urine, which yields an abundant deposit of pus-corpuscles and triple phosphate. The same condition is found in the ureters, possibly in the bladder, nay, even in the urethra. The renal disease is therefore an inflammation which has been propagated from the greater urinary passages. Beginning as a superficial affection, it no sooner extends to the renal parenchyma than it involves all the connective tissue of the kidney; and this, in its turn, culminates in suppuration at various points. The localisation of the suppurative process may possibly be influenced by the more abundant accumulation of connective tissue around the vasa recta and the cortical veins.

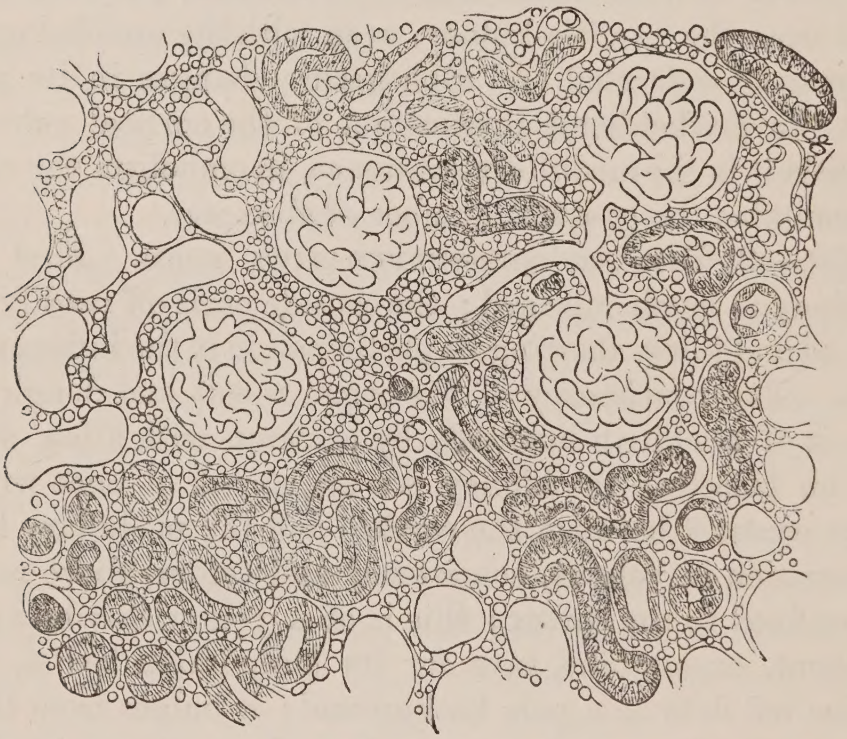
§ 557. Suppurative changes in the kidneys are of course highly dangerous to life; it is obvious, however, that the degree of danger must depend very much on whether both kidneys are affected, or only one. In the former event, death usually occurs from uræmia. In the latter, provided the patient survive, there is the prospect of a further series of structural alterations. A total arrest of the process—inspissation, cheesy metamorphosis, calcareous transformation of the pus and its encapsulation—is only possible within very narrow limits. As a general rule, the pus forces its way into the pelvis of the kidney at the apices of the papillæ. Should this have taken place at more points than one, the medullary cone terminates in the pelvis of the kidney by an ulcerated surface of very irregular form, which increases rapidly in size by necrotisation of the most prominent residual portions of the tissue, and burrows deeply into the parenchyma by progressive suppuration. Should diphtheritic changes already exist in the urinary passages, these are invariably propagated to the denuded surface of the renal parenchyma. The diphtheritic sloughs are detached, but only to give place to new ones. The renal parenchyma is gradually eaten away, a thin layer only remaining to line the capsule.

It sometimes happens (though very rarely) that the pus makes its way through a rent in the capsule. This leads to the formation of inflammatory foci and dependent abscesses in the lax retroperitoneal connective tissue; these abscesses may burst at various points, *e.g.* under Poupart's ligament.

§ 558. *b. Embolic abscesses of the kidney.* The description given in § 556 of pyelitic suppuration needs but trifling modifications to make it equally applicable to the embolic variety. These modifications refer chiefly to the earliest stages of the mischief, the hæmorrhagic element predominating in embolic abscesses of the kidney, just as in the analogous lesions of the lungs. The plug is rarely arrested in one of the main branches of the renal artery; it is usually found in one of the *arteriolæ ascendentes* or even in one of the *vasa afferentia.* The size of the deposit is naturally proportioned to the calibre of the plugged vessel. The disorder sets in with intense hyperæmia, which waxes till blood is actually extravasated into the uriniferous tubes. The extravasation occurs, as a rule, in the centre of the deposit; hence the latter, when recent, presents a central nucleus of a deep red hue, with blurred edges, like a flea-bite in the skin (*Virchow*). At a later period, the centre becomes yellowish-white; suppuration has begun, and leads to the formation of an abscess which no longer differs from the pyelitic variety. In both forms we often find a multitude of abscesses in one Malpighian pyramid while the rest are free. This is explained by assuming that an embolus of considerable size has been splintered against the various forks which it has had to pass; all its fragments having penetrated into the finer ramifications of the affected lobe. On the other hand, the embolic may be distinguished from the pyelitic kidney, even with the unaided eye, by the absence of catarrhal and diphtheritic changes in its pelvis, and by the predominant implication of the cortical substance. In pyelitis it is the medullary substance, in embolism the cortex, which contains the greatest number of abscesses.

§ 559.—2. DIFFUSE NON-SUPPURATIVE FORM. *First stage.* The kidney is much enlarged; the capsule peels off readily; it is thickened and juicy, showing its participation in the inflammatory process. The consistency of the organ is soft and doughy; its surface is of a whitish hue, pale by contrast with a few stellate veins; on bisecting the kidney, we are struck at once with the singular contrast between the cortical and the medullary layers. The alteration in volume, consistency and colour, above referred to, is confined to the cortex; this is of a yellowish-white colour throughout, exsanguine, save for its Malpighian bodies, which look like red dots on a pale background; it bulges from the cut surface, while the medullary cones, though sometimes much congested, are not otherwise altered. In its naked-eye characters, the morbid change we are now considering resembles the parenchymatous form of nephritis very closely (§ 554). The increase in bulk is not indeed so great, the consistency not so soft and flabby, the colour not so yellow, tending rather to a milky-white; but some practice is needed before an observer can distinguish between the two forms on criteria so uncertain. Microscopical examination can never be dispensed with. It shows us that the appearances in question are essentially due to a corpuscular overgrowth of the connective tissue in the region of the convoluted tubes and the Malpighian capsules (§ 546, fig. 159). This overgrowth may roughly be called "diffuse," inasmuch as no section of the renal cortex of any size is absolutely free from it; this, however, does not exclude marked inequalities in the aggregation of the young connective tissue within the limits of a microscopic section; it does not prevent our meeting with places where the accumulation in question has increased the thickness of a septum of connective tissue to two or three times its normal standard, side by side with others which are still quite normal (fig. 159). To the unaided eye, these minor degrees of difference are imperceptible; the multitude of young cells, here as wherever else they exist in large amount, giving the entire tissue a whitish tinge, which is all the more marked in proportion to the emptiness of the blood-vessels. The blood is squeezed out of the cortex just as in parenchymatous nephritis; the post-mortem appearances do not possess an absolute value in either case; they serve merely as a clue to what existed during life; in either case the kidney may be readily and completely injected from its artery. One circumstance alone deserves especial mention here, inasmuch as *Traube* has assigned a direct diagnostic value to it: viz. that the Malpighian tufts are somewhat differently placed from the remaining blood-vessels. They are situated in

FIG. 159.



Corpuscular overgrowth of the interstitial connective tissue. $\frac{1}{300}$.

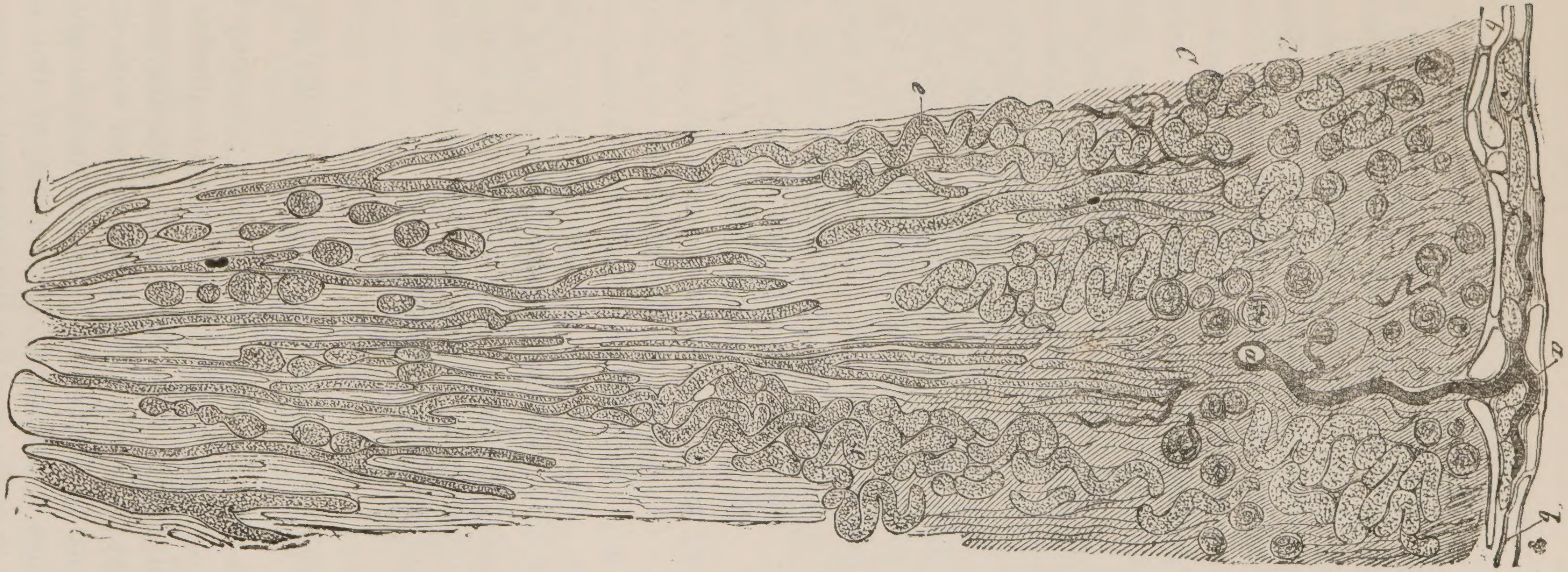
the interior of the uriniferous tubes, and even though they seem ultimately to be very thoroughly constricted (contracted kidney), yet they are at first shielded from external pressure by their intracanalicular position, and therefore continue in a congested state much longer than in parenchymatous nephritis. Their engorgement may even go so far as to cause extravasation, and as the flow of urine into the greater passages is not in the present case hindered by any swelling of the epithelial lining of the uriniferous tubes, the extravasated blood makes its appearance in the urine, and may thus help our diagnosis.

§ 560. *Second stage.* Contraction of the Kidney. The kidney shrinks to one-half, or less than one-half, its normal size; its diminished bulk is rendered more striking when the organ is bisected in the usual way, and the simultaneous enlargement of the hilus thus exposed, due to a retraction of the papillæ and of the columns of Bertin. If we follow *Henle* in regarding the kidney as a sac with disproportionately thick walls, we may say that the inner and outer surfaces of those walls are approximated to each other, a phenomenon only rendered possible by a contraction of the substance of the sac itself. The capsule is very adherent in parts; it is of a whitish tint, tough, and furnished with tolerably capacious vessels which inosculate with those of the perinephritic adipose tissue. The surface of the kidney is irregularly granular. The hemispherical protuberances vary in diameter from one-tenth of to half a centimetre; their colour is a yellowish-grey, while the retracted intervals exhibit a pure grey or reddish hue. The leathery toughness of the entire organ is very striking; here and there, we find cysts which may reach the size of a cherry, filled with clear straw-coloured, or grey and purulent contents. On cutting the kidney in two, we find that the diminution principally affects the cortical layer. This may shrink to such an extent as to form a layer only a line in thickness over the medullary cones.

§ 561. The annexed drawing (fig. 160) exhibits a segment of a longitudinally divided kidney, including about three lobules, under a low magnifying power; the length of the *arteriola ascendens* (*a*) corresponds to the thickness of the cortical layer. The vessel is tortuous and dilated; it gives off several equally tortuous *vasa afferentia* to the Malpighian bodies which are still pervious, while the greater part of the blood (in the present case of the injecting fluid) has made its way into the capsule of the kidney. The latter is much thickened, and permeated throughout by blood-vessels and lymphatic spaces, which give it the aspect of a perforated network (fig. 160, *b*). The main bulk of the cortex is made up of connective tissue, represented by shaded lines in the drawing. Embedded in this connective tissue we notice, 1st, the shrivelled remains of a number of Malpighian bodies, presenting the aspect of concentrically laminated spheres of connective tissue of various dimensions (*d*) (§ 546) ; and 2nd, a few scattered tufts of convoluted uriniferous tubes, greatly dilated, which have escaped the general disorganisation. At *c* is the cortico-medullary boundary; the medullary substance forming five-sixths of the entire thickness of the organ. This, too, is in nowise healthy. We perceive, first of all, the dilatation of the efferent canals and their ramifications. The elaborate tufts and convolutions here and there exhibited by this system of canals (*e*, *e*) forces the notion of a vicarious development on the observer's mind. At any rate, these are the passages along which the very great quantities of urine, which are often secreted in the second stage of Bright's disease, are voided. The compensatory effort can never be really adequate ; its efficacy depends essentially on the chances of voiding, together with an enormous amount of the transuded water of the blood, a proportionate amount of the urinary solids; the associated loss of albumen being only less hurtful to the organism than the retention of the urea, &c., in the blood. But even to allow of this dearly-bought compensation, it is needful that passages should exist through which the transuded matters may escape ; and these passages are the tortuous and dilated efferent canals.

The looped tubes are either unaffected, or they may exhibit that cystoid degeneration of their flexures which has been described more fully in § 540, and which is ushered in by the colloid metamorphosis of impacted cylinders of fibrin. The annexed figure (*f*) shows a number of these minute cysts, partly arranged in beaded rows, scattered through the immediate neighbourhood of the papilla.

FIG. 160.



Contraction of the kidney. A bit of the principal section of a contracted kidney, including about three lobules from their base to their apex. *a. Arteriola ascendens;* *b.* Capsule of the kidney permeated by lymphatic spaces; *c.* Cortico-medullary boundary; *d.* Glomeruli, shrunken and embedded in connective tissue, which has also replaced the other textural constituents of the cortex, leaving only a few uriniferous tubes; *e.* Portions of convoluted tubes in the medullary layer, produced by the dilatation of the efferent canals; *f.* Gelatinous cysts in the papilla.

d. *Combination of Parenchymatous with Interstitial Inflammation.*

§ 562. Owing to the great similarity of the naked-eye characters presented by a kidney in the first stage of a purely interstitial nephritis, to those exhibited in parenchymatous inflammation, the two forms have often been confounded; hence the notion of a continuous morbid process, beginning with parenchymatous swelling and terminating in contraction. It is not by any means my intention to question the possibility, or even the frequency, of such a combination; I need only insist upon its being a combination of two states which may also occur independently. As an example in point I will cite the so-called "mottled kidney," which originates in the combination of a moderate degree of contraction, with fatty degeneration of the tubular epithelia. The size of the kidney is but little altered; it is rather below than above the normal standard; tolerably hard and inelastic to the touch. The capsule may be stripped off with but little loss of substance. The surface is beset with countless granular elevations, which attain an average height of one millimetre; they are convex, not always round, but curiously whorled. They are of an intense yellow colour, which contrasts very markedly with the reddish-grey of the intermediate parts. On section, we find that this singular alternation of yellow and reddish-grey extends throughout the whole of the cortex. Microscopic examination proves that the yellow parts consist of uriniferous tubes filled with oily matter, while the reddish-grey substance between them is made up of tolerably vascular connective tissue, as well as of obliterated uriniferous tubes and Malpighian tufts.

e. *Combination of Amyloid Degeneration with Interstitial Nephritis.*

§ 563. This is a very frequent combination; it may be explained by supposing that the amyloid change is primary, and goes on till the Malpighian tufts have undergone degeneration, when the interstitial nephritis becomes associated with it. The mechanical hindrance to the flow of blood through the glomeruli gradually determines a collateral hyperæmia of the cortical substance, and so paves the way for the corpuscular overgrowth which ensues, either directly, or in consequence of some superadded inflammatory irritant.

The anatomical appearances differ from those in the first stage of a simple interstitial nephritis, by the red colour taken by the glomeruli on the addition of iodine, amid the yellowish-white and swollen cortical substance; while side by side with the contraction of the kidney, we can usually distinguish an infiltration of the renal papilla with amyloid matter (§ 539).

f. *Complete Amyloid Infiltration.*

§ 564. This is very rarely met with. I have only seen one case of it; the preparation is in the Physiological Institute at Breslau. The kidney is enlarged to nearly twice its normal size; it is very pale throughout, waxy, and—what struck me as being especially characteristic—the bases of the Malpighian pyramids were as sharply separated by intermediate depressions as in the fœtal kidney. The application of iodine showed that all the homogeneous membranes, those of the capillaries as well as the basement-membranes of the uriniferous tubes, were impregnated with amyloid matter.

3. TUMOURS.

§ 565. (*a.*) *Cysts.* No organ of the body is so rich in occasional cystic formations as the kidney. It not unfrequently happens at post-mortem examinations, that we are surprised by the unexpected discovery of solitary cysts in the kidney, characterised by their perfectly transparent straw-coloured or colourless contents, and the extreme thinness of their walls. We know hardly anything about their mode of origin and real nature. Inasmuch as the rest of the renal tissue is perfectly healthy, exhibiting at most only certain hollows caused by the mechanical pressure of the cysts on the parts immediately surrounding them, we must resign all hope of obtaining light from this quarter. Microscopic examination of the cyst-wall shows a thin layer of fibrous connective tissue, lined by a polygonal pavement-epithelium of great beauty. On chemical analysis, the cysts are found to contain none of the urinary solids; their contents yield albumen, and varying quantities of leucin and tyrosin. All the remaining varieties of cysts are developed from the uriniferous tubes. With the solitary exception of cystoid degeneration of the fœtal kidneys, they occur as complications of inflammatory changes, under which they have already been discussed (§ 540, *et seqq.*).

§ 566. (*b.*) *Cavernous Tumour.* Analogous to cavernous growths in the liver, tumours varying in size from a cherry-stone to a walnut, consisting of erectile tissue, are occasionally met with in the kidney. From a clinical point of view they are unimportant. They are chiefly situated on the outer surface of the organ, immediately beneath the capsule.

§ 567. (*c.*) *Fibroma.* In the midst of a perfectly healthy kidney, we come upon solitary nodules of connective tissue of a lustrous white colour, very dense and tough, varying in size from a pea downwards. They are nearly always situated in the neighbourhood of the larger vessels, in the outer part of the medullary substance. *Virchow* ascribes them to a circumscribed interstitial nephritis, the uriniferous tubes being traceable into the interior of the growth.

§ 568. (*d.*) *Leukhæmic Tumours. Lymphoma.* In extreme cases of leukhæmia we find, together with similar changes in other organs, white marrowy tumours in the kidneys, consisting of colourless blood-corpuscles embedded in a very delicate reticulum. They are either globular, when they vary in size from a mere dot to a small cherry, or they may conform outwardly to the structure of the kidney, by equably filling up the interstices between the lobules, and hence assuming a more elongated or even wedge-shaped form. The view expressed above (§ 524), that the case is really one of extravasation, is singularly confirmed by the fact that a mass of red corpuscles may very commonly be detected in the centre of these little tumours. (An observation made by *Virchow* which I corroborate from personal experience.)

§ 569. (*e.*) *Tuberculosis.* Disseminated form. Grey, translucent, miliary nodules are uniformly but sparingly distributed through the renal parenchyma. They are developed in the sheaths of the minute arteries, and elsewhere in the connective tissue, and owe what interest they possess to their association with general miliary tuberculosis.

Localised form. (*Phthisis renalis.*) Among the morbid appearances which go to make up what is known as "tuberculosis of the genito-urinary apparatus" is an affection of the kidneys, which, both in its minuter characters and in its coarser effects, ranks with the disorder of the mucous membranes described in § 383. The tubercular eruption begins in the papillary portion of the kidney, to which it is propagated from the mucous lining of the calyces. The closely aggregated groups of grey granulations form at first a continuous infiltration ; ~~they~~ then undergo caseation ; and this often occurs simultaneously over a considerable tract, so that we may distinguish zones of cheesy matter quite a line in thickness. The softening and removal of the cheesy matter is associated with softening and extrusion of a corresponding amount of the renal tissue. There results a true tuberculous ulcer of a putrid kind, which burrows deeply into the substance of the organ, eroding first the medullary substance, and after that the cortex. In extreme cases of *phthisis renalis* the kidney forms a thick-walled sac with hemispherical protrusions, each of which corresponds to a Malpighian pyramid. A continuous ulcer, occupying the interior of the sac, likewise extends to the surface of the pelvis and ureter, while the projecting folds which separate the individual calyces from one another are partly destroyed, partly pressed back upon the wall of the sac. Of the renal parenchyma, there may remain only a scanty residue of cortical substance to line the capsule ; or it may have wholly disappeared, the floor of the ulcer being formed by the thickened capsule itself, which is, moreover, studded throughout with tubercles.

§ 570. (*f.*) *Carcinoma.* Cancer occurs in the kidney in all forms, both primary and metastatic. Foremost in importance are the primary soft cancers. These are not common, but owing to their position and size, they necessarily give rise to the most serious disturbances when they do occur. Cancerous kidneys may attain dimensions of twelve inches by six. Owing to the uniform distribution of the cancerous deposits, the kidney usually retains its proper form, at least in its broader outlines ; in other cases we remark single nodules of colossal size, each of which replaces a Malpighian pyramid, side by side with smaller deposits which correspond only to groups of lobules. That the morbid products do really take the place of the normal tissue, not merely pushing this aside, is clearly shown by the fact that we can still recognise, in the interior of a cancerous nodule, what part of it was formerly medullary substance, and what part cortical. This marked character of substitution, exhibited by renal cancer, is so far interesting in regard to the histological features of its genesis, as it supports the view recently adopted by *Waldeyer*, who regards the epithelioid elements of the tumour as the direct progeny of the renal epithelia. *Waldeyer* succeeded in isolating fragments of a network of cancer-cells, beset with sprout-like processes, which he took to be cylinders of tubular epithelium thickened by an autochthonous proliferation. Cancer of the kidney, in common with other cancerous growths, had hitherto been believed to originate from the connective tissue; the retention of the main features of the organ being explained by the uniform distribution of the substance undergoing degeneration—the connective tissue (*see* § 69, A 1).

§ 571. Cancers of the kidney, like those of the liver and testicle, are characterised by their richness in wide and thin-walled capillaries. These vessels are occasionally torn; the blood escapes in variable quantities, a part of the tumour being studded throughout with such extravasations. Hence it is, that the term "fungus hæmatodes" has so often been employed to designate cancer of the kidney. It is worthy of note, moreover, that soft cancer of the kidney is especially prone to invade the efferent canals, veins, and calyces, a tendency which occasionally gives rise to very serious clinical symptoms. For should the tumour extend along the renal vein, it must ultimately reach the inferior cava. It then protrudes into the latter vessel; fragments are readily broken off and carried away by the blood-current. This accident is inevitably followed by pulmonary embolism. Should the cancer, on the other hand, project into the greater urinary passages, it commonly gives rise to periodical attacks of hæmaturia which seriously accelerate the progress of the cachexia towards a fatal issue.

IX.—MORBID ANATOMY OF THE OVARIES.

1. Inflammation.

§ 572. The physiological activity of the mature ovary is attended with phenomena which, if they occurred in any other organ, we should not hesitate to call "inflammatory." The functional hyperæmiæ with which we are familiar in the mucous membrane of the alimentary tract, in the liver, kidneys, &c., cannot be compared, as regards intensity, with that active congestion of the ovaries which accompanies ovulation. The rupture of the follicles, without which the ova cannot be discharged, is a spontaneous laceration; blood is poured out; and it is only by a gradual process of repair, a process which is the physiological prototype of healing by granulation, that the continuity of the parts can be restored. The associated phenomena of menstruation, moreover, exhibit the characters of a violent disturbance of vegetative equilibrium. All this shows that it is as difficult for the physician as for the anatomist, to draw a hard and fast line between physiological and morbid, especially inflammatory changes in the ovary. Their intimate relationship is clinically proved, as well by the fact that the processes connected with the extrusion of the ovum may take on an inflammatory character by a simple increase in degree, as by the circumstance that the true inflammations of the organ present the symptoms of "pseudo-menstrual" states. The anatomist has to beware of misinterpreting hyperæmic and hæmorrhagic phenomena, when confined to single follicles; he must be careful not to misunderstand thickenings of the *tunica albuginea*, and puckered cicatrices on the surface of the organ; he must not be too hasty in assuming the existence of atrophy and hypertrophy; since all these appearances are manifested in some measure during the natural evolution and involution of the ovary.

§ 573. Suppurative oophoritis, such as occurs during the puerperal state, is unquestionably inflammatory. The change presents but little of histological interest. A thorough saturation of the organ with sero-fibrinous exudation causes it to swell, often very considerably; on section, the ovarian stroma looks sodden and œdematous. We notice purulent striæ along the vessels, extending from the hilus to the periphery; or else circumscribed collections of pus—minute abscesses—may be already present; and these, especially when near the surface, threaten to burst into the peritoneal cavity. In the majority of cases, however, a suppurative peritonitis is already present, and has enveloped the inflamed ovary in a mass of fibrino-purulent exudation. The follicles attract attention by their intensely swollen and congested state; they give one the idea that the inflammatory action is peculiarly concentrated upon the secreting tissue. Under these circumstances, the contents of the follicles are rendered turbid by the admixture of cells detached from the *membrana granulosa;* so that, upon the whole, the morbid changes might legitimately be included under the head of "catarrhal inflammation." Our general knowledge concerning inflammation terminating in suppuration and abscess, catarrh, &c., enables us to form a very accurate notion of the histology of the process; it is only the *consequences,* therefore, which a favourable attack of oophoritis necessarily entails on the affected ovary, which demand any special attention at our hands.

An inflammatory proliferation, however rapidly it may have run its course, invariably leaves a condition of increased vulnerability behind it; this shows itself in a proneness to a relapse of the original inflammation, or to the occurrence of changes of a more hyperplastic character. The connective tissue of the old stroma is actually replaced in parts by a young embryonic tissue, rich in cells; the greater abundance of corpuscular elements involves a greater irritability of the organ. Now if we reflect that the ovary is periodically exposed to recurrent congestions of great intensity—if we reflect that its physiological alterations are, so to say, synonymous with inflammatory states, we can easily understand how exceptionally it is predisposed to hyperplastic changes of all sorts, following on the heels of acute inflammation; changes which set out from the connective tissue of the organ, and are concentrated, now in the stroma proper, now in the follicular capsules.

§ 574. Overgrowth of the ovarian stroma may cause a uniform enlargement of the organ to the size of a closed fist; indeed, cases of this kind have been recorded as "hypertrophy of the ovary." More commonly, however, it leads to a contraction which lessens the size of the organ in all its dimensions, and is analogous to cirrhosis and granular atrophy of the liver. An increased toughness, a milk-white lustre, and a surface more or less lobulated, studded perhaps with little polypoid excrescences, afford good evidence of the simultaneous (and often predominant) implication of the cortical layer. *Virchow* asserts that the thickening of the albuginea extends to the collapsed theca of the ruptured follicle, wherever the surface is puckered by the cicatrix of a former ovulation. And yet, as I have already said, it is very hard to draw a line between what is "normal" and what "inflammatory" in such a case as this. *Rokitanski* was the first to notice that the *corpora lutea* might serve as centres and points of origin for fibroid tumours; his observations have since been repeatedly confirmed.

§ 575. Hyperplastic states of the connective tissue, and in particular of the CAPSULES OF THE UNRUPTURED FOLLICLES, have often been observed and described; but they have never been definitely referred to antecedent ovaritis. And yet the very frequent concentration of acute ovaritis upon these capsules would naturally suggest some causal relationship between them. The circumstance that those follicles which have put on the appearance of cysts, owing to an accumulation of fluid in their interior, are principally affected by capsular thickening, is rather in favour of than against this view. For the capsule which has undergone inflammatory thickening, unquestionably offers a more determined resistance to those forces which tend to make the follicle burst. This explains why the follicles do not give way; the amount of fluid they contain may go on increasing; the increased pressure from within, instead of causing rupture, will rather give rise to a further degree of compensatory thickening of the capsule. The disease thus enters on a vicious circle; it may finally issue in the first variety of ovarian cystoid (§ 579).

2. Cysts.

§ 576. Next to the kidneys, the ovary is the most favourite seat of cystic formations of various kinds. We find cysts large and small, simple and compound; cysts with watery, colloid, fatty, sanguinolent or mixed contents. The unbiassed observer will naturally be prone to refer this tendency to cystoid change, to the circumstance that the normal ovary contains the rudiments of cystic structure in its follicles. Careful investigation shows that the majority, at any rate, of all ovarian cysts originate in the Graafian follicles; on the other hand, it proves that a group of cysts, quite as important, though not indeed as numerous, must for the present be assigned to a very different source. In the foregoing paragraphs I have tried to show how a hyperplastic state of the follicular walls, excited by inflammation, may, or rather must, give the first impulse to the development of a cyst. I do not fail to appreciate, indeed, that it is upon a disproportion between the forces which have to rupture the follicle, and the resisting power of its capsule, that the issue ultimately depends. The follicle will also fail to burst, and will degenerate into a cyst, if the centrifugal force be inadequate; and this is apparently the cause of that form of dropsy of the follicles of which I am about to speak. What makes the follicular walls give way? Can it be a transudation of fluid from the vessels? That were impossible—at least if we are to suppose that the increase of tension in the interior of the follicle is directly due to a transmission of the blood-pressure to its contents. Such a theory would be incompatible with the laws of osmosis. We may justly assume, however, that during menstruation a chemical compound (colloid?), endowed with a capacity for swelling by imbibition, may be secreted by the cells of the *membrana granulosa* of the ripe follicle; that this substance takes up the water abundantly transuded from the vessels, and bursts the follicle by its expansion, in much the same way as a skull is disarticulated by filling it with dry peas, on which water is then poured. Granting this assumption, we may go on to suppose that in certain individuals the substance in question is not generated in sufficient quantity, and that the active forces designed to burst the follicle are thus inadequate for the fulfilment of their purpose.

So much for the origin of ovarian cysts from Graafian follicles, which is still under discussion. Let us now pass on to consider the individual forms of the disease.

§ 577. A. HYDROPS FOLLICULORUM (dropsy of the follicles). Certain cysts of the ovary are chiefly characterised by the watery nature of their contents, which are closely related in their chemical composition to the serum of the blood; these cysts are undoubtedly the most common of all those which affect the ovary; they are usually discovered by accident, inasmuch as they do not give rise to any marked symptoms calling for surgical interference. Even in new-born infants, we not unfrequently find small examples of these smooth and thin-walled, sparingly vascularised blebs. In adults, they may either be solitary or multiple. The affected ovary may reach the size of a child's head; but it does not usually exceed that of a closed fist. The most conclusive proof that the disease is really a dropsy of the Graafian follicles, is that given by *Rokitanski*, who succeeded on one occasion in detecting an ovum in all the cysts which were less than a bean in size.

§ 578. B. OVARIAN CYSTOID (*Cystoma ovarii*). By this name we denote a tumour wholly made up of cysts, or consisting of a single cyst, which takes the place of an entire ovary, and originates in a degeneration of the ovarian texture, which, at least in its final stages, is of a cystic nature. Inasmuch as the size and weight of these tumours usually exceed the ordinary limits of morbid formations by a great deal, and call for operative measures of the most dangerous kind, they are justly numbered among the most important diseases of the ovary. Moreover, the study of this group of tumours furnishes us with a series of appearances of the greatest anatomical interest; indeed, it appears to be reserved for the anatomist to establish a rational classification of cystoid tumours of the ovary on a histological foundation. Much importance used formerly to be attached to the question whether a cystoid tumour of the ovary was made up of one or more cysts, whether it was unilocular, or multilocular; we are now aware that this distinction, important as it is for practical ends, is not of any fundamental moment. It has been shown that the simple cystoid is not simple from the first, but that it originates in the progressive fusion of several contiguous cysts. All cystoid tumours are at first multilocular. We will therefore assign only a subordinate place to this principle of classification, while admitting that the process of fusion, alluded to above, is undoubtedly most frequent in that form of cystoid disease which depends on a colloid degeneration of the Graafian follicles (Form I.).

The naked-eye characters of cystoid tumours of the ovary depend, in the first place, on the size and number of the cysts. A simple cyst is globular; two or more yield a rather elongated form, and give the surface an irregular appearance, studded with hemispherical protuberances. The contained fluid shines through the walls of the cysts, giving them a yellow tint, or some shade of brown; on pricking the tumour, the tense walls of all the cysts collapse; for the latter communicate with one another far more freely than we might *a priori* anticipate. The contents of the cysts are of course an object of chemical rather than of anatomical investigation. The chief chemical constituent is that still so mysterious albuminoid substance known as "colloid" *par excellence*, or some one of its modifications (*see* § 44). The beautiful researches of *Eichwald* have proved conclusively that in cystoid tumours of the ovary, two series of chemical transformations are usually progressing side by side; the colloid matter generated by tissue-metamorphosis being gradually converted into mucous peptone, while the albuminous matters transuded from the blood are undergoing transformation into albuminous peptone. The steady action of the heat of the body is enough, therefore, to bring about a sort of slow digestion of these "crude" products. The larger and the older the cysts, the more likely are we to find such soluble modifications of albumen in them, involving a greater fluidity of their contents. The solid matters, which are often suspended in considerable quantity in the fluid contents of the cysts—such as free cells and nuclei, crystals of cholesterin, oil-globules or oily *débris*, blood-corpuscles, pigment—are all secreted by the lining membrane, and may always be referred, partly to a desquamation and fatty metamorphosis of epithelial elements, partly to the occurrence of hæmorrhage.

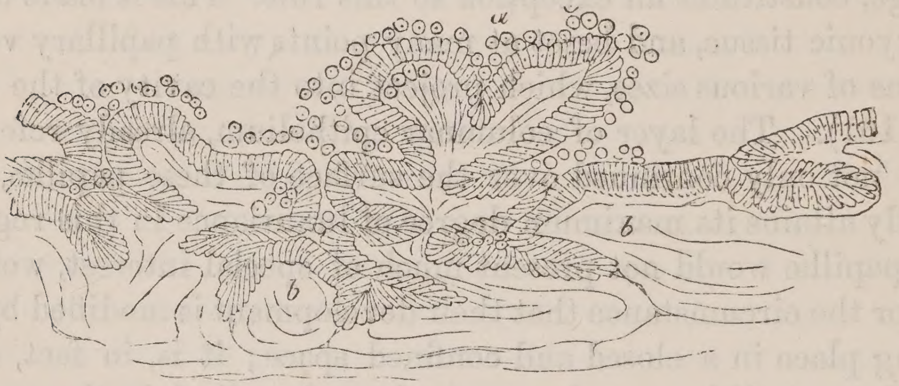
All further peculiarities of ovarian cysts must be discussed under the individual varieties of the disease, of which we are now able to enumerate three. (Cf. *Mayweg's* Prize Essay, Ueber die Entwicklungsgeschichte der Eierstockcystoide. Bonn. 1868. *Waldeyer*, Eierstockcystome.)

§ 579. Form I. Multilocular tumours reaching the size of a man's head, or unilocular cysts which may be two feet in diameter, with a smooth surface little broken by adhesions, and comparatively thick, fibrous walls, which are very commonly lined with cauliflower excrescences, or more knobby papillose growths.

The smaller cysts contain a highly concentrated colloid matter of an amber-yellow tint; the contents of the larger cysts are more fluid, and mingled with abundant fatty and corpuscular products, secreted by their walls. The corpuscular elements are invariably derived from a simple, non-laminated layer of columnar epithelium, which lines the walls of the cysts, and is continued over all their irregularities.

If we make a vertical section through the entire thickness of the cyst-wall for purposes of microscopic investigation, we see at once that it is almost wholly made up of a well-developed connective tissue, arranged in stratified lamellæ. The average thickness of these lamellæ is ·003 mm. It is only the innermost, subepithelial layer which, at least in all cysts below the size of an orange, constitutes an exception to this rule. This is made up of embryonic tissue, and beset at many points with papillary vegetations of various sizes, which project into the cavity of the cyst (fig. 161). The layer of columnar epithelium, already referred to, is not only continued over the surface of these papillæ, but usually attains its maximum degree of luxuriance in this region. The papillæ would not present much of special interest, were it not for the circumstance that their development is modified by its taking place in a closed and confined space; it is, in fact, subjected to conditions analogous to those described in the case of *papilloma cysticum* (§ 70). It is plain that papillæ which grow from the inner surface of a spherical cavity, must converge, and ultimately come into contact with one another. Contact will take place all the sooner in proportion as the papillæ tend to break up into branches, to spread out in an arborescent form. Both of these conditions are fulfilled in the present instance; and the result is, that the tips and sides of the papillæ coalesce with one another at an early period and in a variety of ways. Hence, too, the larger, pedunculated tumours (which may attain the size of a closed fist), occasionally met with in the interior of the cysts, often exhibit a smooth surface with only the faintest traces of lobular division; and yet, on examining them in transverse section, we find them to be most undoubted papillomata. But even the smaller papillæ, which barely project above the level of the surface, are often united at their tips; hence even these may exhibit a phenomenon alluded to in § 70 as a frequent result of such coalescence, *sc.* the development of retention-cysts. The lacunar interstices lined with epithelium, which we find close to the inner surface of such cysts, and even to some little distance from it—originally described by *Rokitanski*, and more recently by *Fox*, as the rudiments of so-called "daughter-cysts"—are in my opinion to be regarded as former interpapillary spaces. The continuous ingrowth and thickening of the surface-tissues has, so to say, outrun these interpapillary spaces before their complete obliteration had time to occur; the minute residue of free epithelial lining being sufficient to keep up an independent secretion and so to cause the development of cysts. Indeed this is the only way in which fresh cysts can be produced in addition to those originally formed, in this, the first form of colloid disease of the ovary; and if we take into account the very sparing production of such daughter-cysts, we may even assign a purely accidental significance to the entire phenomenon; nay more, we may lay stress on the fact that the first form of ovarian cystoid differs from the second by a certain limitation in the number of cysts, and by the recession of all such changes as might tend to increase their number. All this is ultimately reducible to the origin of this first variety of colloid disease of the ovary from a limited number of Graafian follicles.

FIG. 161.



Section through the innermost layer of an ovarian cyst as big as an orange, which has originated by the colloid degeneration of Graafian follicles; *a*. Papillary outgrowth, slightly compressed, coated with columnar epithelium; *b*. Sub-epithelial layer of connective tissue, also split into papillæ, and traversed by interpapillary fissures lined with epithelium, which are not unlike gland-tubuli. $\frac{1}{200}$.

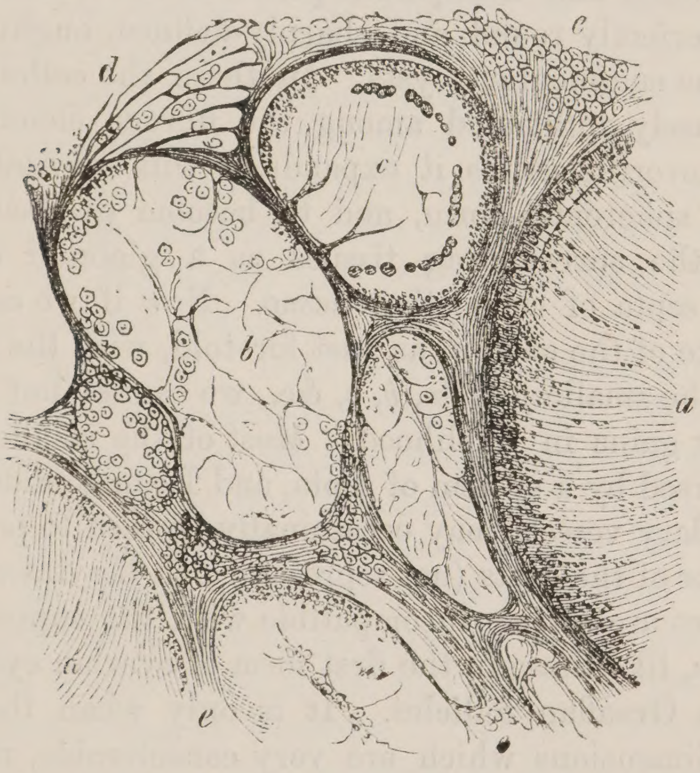
§ 580. The discovery of ova in the smaller, primary cysts, would be the most conclusive proof of the correctness of this view; hitherto, however, the search has only been successful in one instance, where an ovum was found in a cyst about the size of a cherry. At the post-mortem examination of a woman who died after the removal of a cystoid tumour of the right ovary, I found the left ovary in an earlier stage of the same disease; and it was here that I came across the cyst in question. The current of indirect evidence flows more strongly in our favour. To begin with, in the present form of cystoid degeneration, we never find cysts, however rudimentary, below the ordinary size of Graafian follicles. Again, the very smallest cysts are lined with a continuous epithelium, which, from the form and stratification of its constituent elements, may claim to rank with external or glandular epithelium (as contrasted with endothelium), like which, moreover, it is subject to periodic renewal. Finally, we have the extensive analogy between these growths and the cystosarcomata of certain open glands, in particular of the mammary gland and testicle. The intracanalicular development of papillomata which characterises *e.g.* the *Cystosarcoma mammæ phyllodes*, exists in the present case also; with the sole difference that in the ovary, owing to the Graafian follicles being closed cavities, the formation of cysts takes a more prominent place than in the mammary gland. What can be more likely than that the preformed gland-tissue, *i.e.* the follicles, should, in the ovary, as in the mamma, be the starting-point of the disorder? I may mention by the way, that the greater frequency of unilocular cysts in this first category, is explained by the fact that, owing to the limited number of the follicles, the possible number of cysts is from the first restricted—though often very considerable; these cysts, when they have reached a certain size, become confluent by atrophy of their partitions; this coalescence being repeated until the whole supply of existing cysts has been used up; the final result, owing to the non-development of secondary cysts, being a single sac, often of colossal magnitude.

§ 581. The only question which still requires an answer, is that concerning the origin of the colloid matter. Whence is it derived? Is it secreted by the epithelial cells? or does it result from the involution of all the older epithelial elements? Does their protoplasm undergo colloid metamorphosis, and so fill up the interior of the follicle? I am decidedly in favour of the view which makes the colloid matter, like mucus, a secretion of the glandular elements. Indeed I believe that the cells of the *membrana granulosa* normally secrete a certain quantity of this substance at the time when the follicles burst; for it would be difficult to account for their rupture, without assuming the presence of some material capable of expanding rapidly by imbibition. To substantiate this hypothesis, however, it would be necessary to prove the actual presence of a sufficient number of epithelial cells in a state of colloid degeneration (fig. 12); this has not yet been done, though quantities, often very great, of detached though otherwise unaltered epithelial cells, have frequently been met with in the contents of the cysts.

§ 582. Form II. One of the ovaries (the other, as a rule, being perfectly healthy, while in Form I. the disorder is usually symmetrical) is replaced by a large tumour, often bigger than a man's head, made up of a few large cysts, together with a great number of smaller, even of very small ones. The larger cysts are often narrowed at some point where the remnants of former septa, in the shape of fenestrated membranes or of branching, vascular cords, obviously undergoing gradual maceration, may be observed. The surface of the tumour is nearly always connected with the peritoneum by a large number of inflammatory adhesions, traversed by veins of considerable size. The walls of the cysts are relatively thin and lacerable; their inner surface is smooth, often pigmented. In the gelatinous contents of the smaller cysts, we here and there notice gauzy films stretching across the cavity like cobwebs. The smallest cysts can only be detected with the aid of a microscope. Here, as in the first variety, the contents of the larger cysts are more fluid than those of the smaller ones; the only feature which may be called characteristic of the present form, being the frequent admixture of blood and blood-pigment with the contents of the cysts.

§ 583. On examining fine sections from the tougher portions of the tumour under the microscope, we soon become aware that continuous tracts of fibrous and well-organised connective tissue are rare even in such parts as are white and tolerably dense, whether forming the outer wall of the tumour, or one of the broader trabeculæ in its interior. All these parts, indeed, are made up of connective tissue; but throughout this connective tissue a number of minute cysts are disseminated, which we are able to follow up to their very first beginnings (fig. 162). The annexed drawing represents the minute structure of one of the trabeculæ of the stroma, which separates two cysts of considerable size (*a*, *a*) from one another. We see at a glance that the striated connective tissue forming the main bulk of the structure, breaks up into a great number of finer trabeculæ, which enclose and traverse a group of smaller cysts. Of course we must not think of these trabeculæ as cylindrical; indeed, they are only trabeculæ in seeming, being really membranous partitions of variable thickness, seen in transverse section. Here and there (*e*, *e*) the connective tissue is abundantly infiltrated with young round-cells, a proof that it is in a state of formative irritation. One might easily be led to suppose that some of the larger clusters of these cells (*e*) represent cysts in the earliest stage of their development—rudimentary cysts. For some of

FIG. 162.



Colloid degeneration in the stroma of an ovarian cystoid. *a a.* Large cysts, lined by an imperfect epithelium of sub-columnar cells; the contents of the cysts exhibit a radial cleavage after hardening; *b.* Younger cysts devoid of an epithelial lining, and traversed by remnants of connective-tissue fibres; *c.* Ditto, with a ring of detached epithelial cells; *d.* Colloid infiltration of the connective tissue, which has not yet reached any cyst-like form and differentiation; *e.* Infiltration of the stroma with small cells. $\frac{1}{200}$.

the smallest cysts (to the left of *b*) look just as if a certain amount of colloid matter had simply made its way in between the constituent elements of one of these little clusters, and had pushed them asunder. Some authors, indeed, have adopted this view. For my own part, I would advise the utmost caution. The knife may have passed through the extreme end of a larger cyst and so given rise to the semblance of a very small cyst. I do not on that account propose absolutely to reject the possibility of such an origin; but I would rather extend the limits of my definition, and only speak in general terms of a circumscribed colloid softening of the stromal connective tissue, as the first stage in the development of the cysts. For it seems to me that certain swollen and transparent points in the stroma (*d*) which are not perfectly round and sharply-defined, ought also to be regarded as rudimentary cysts. In these, the colloid matter is more diffusely infiltrated among the fibrous elements of the stroma; nevertheless, as it expands, it will inevitably tend to assume a spheroidal form, and to become gradually marked off from the surrounding tissues as a globular cavity traversed by septa of connective tissue. Now if we compare the future state of the spot, *d*, as just foretold, with the actual condition of the smallest cysts, *b*, *c*, &c., we cannot but admit that our theory gains in likelihood. Most of the smaller cysts are still traversed by a system of septa, and I can confidently affirm that capillary vessels may occasionally be seen to pass through the interior of the cysts (not represented in the drawing). Such appearances are utterly incompatible with the supposition that these cysts, like those in the first form of ovarian cystoid, originate from Graafian follicles. It is only when the cyst has reached dimensions which are very considerable, relatively to these first rudiments, that it begins to remind us of a Graafian follicle. *Waldeyer* is accordingly obliged (*die epithelialen Eierstocksgeschwülste, insbesondere die Cystome*, Archiv f. Gynækologie, Bd. i. Heft 2) to go back to the earliest stages in the development of the Graafian follicles; he finds that they originate in certain minute and very irregular masses of epithelium, embedded in the fœtal ovary; he has also discovered them in the apparently healthy residue of a cystomatous ovary. I would willingly adopt his views, did not my own observations, which I have recorded above (fig. 162, *d*) warn me to be cautious. For in the larger cysts we always find a layer of epithelium, however imperfect; and the colloid matter, apart from any fibrous admixture, presents a laminated appearance in hardened specimens, which points to its having been secreted by the lining membrane. There are other reasons, too, which render it undoubted that the cysts, after they have reached a certain size, are to be viewed as secreting cavities. How else could we account for the quantity of albumen in all the larger cysts, save on the hypothesis that it transudes from the vessels, and is therefore secreted by the cyst-wall? Notwithstanding all this, the cysts do not originate from follicles; their development is due to that transformation of "cysts due to softening" into secreting cysts, which is more fully described in § 70. Finally, to sum up the results of our inquiry, we conclude that the second form of cystoid of the ovary, characterised by the unlimited production of new cysts, is due to a colloid degeneration of the ovarian stroma; not forgetting the possibility that the rudiments of the cysts may be furnished by an epithelial proliferation, closely resembling that which normally occurs in the embryo. In the latter case, we might term the disease a *Carcinoma colloides cysticum.*

§ 584. Form III. Both ovaries are found equally affected by a kind of "cysto-colloid" degeneration. They are larger than a man's fist; their surface is smooth; a large number of cysts, varying in size from a millet-seed to a pea, and packed together like the bits of stone in a mosaic, are seen shining through the tunica albuginea. In transverse sections, this mosaic is found to extend through the entire thickness of the organ; the largest cysts, which may attain the size of a cherry, being situated towards its centre. The entire structure reminds us of a honeycomb. The contents of the cysts are clear and gelatinous throughout; so that the term "colloid of the ovary," chiefly employed to denote the two former varieties of cystoid disease, may not inaptly be applied to this form also. This third variety is very rare; and hence it is, in all likelihood, that we possess no certain knowledge concerning the origin of the cysts. The solitary specimen at my disposal has been soaked in weak spirit for so long a time, that no trustworthy results can be arrived at by examining it. The naked-eye appearances are very much in favour of the Graafian follicles having been the starting-point of the mischief; not even the smallest of the cysts falls below the Graafian follicle in size; moreover, each cyst has its own tough, membranous capsule; and finally, the arrangement of the cysts, alluded to above, with the smallest ones at the periphery and the largest ones in the middle, forcibly recalls the very similar arrangement of the Graafian follicles. I am inclined to term this condition *struma ovarii*, in *Virchow's* sense of the word *struma*.

§ 585. c. DERMOID CYSTS OF THE OVARY. These are unilocular cystomata, whose walls resume the textural and structural conditions of the skin. The skin, with its appendages, forms a closed sac with its free surface turned inwards. Most of the dermoid cysts which have been hitherto observed, have not been bigger than an orange; occasionally, however, they attain a colossal size (that of a man's head). Their growth depends only in part on the proliferative processes occurring in their walls; another factor is the accumulation of cutaneous secretions in their interior. They usually contain a greasy pulp resembling the *vernix caseosa*, made up of detached epidermic scales with sebaceous matter. This is mingled with long hairs, generally of a reddish-blond colour, very thin, curled up, or matted together.

The *epidermis* exhibits its typical differentiation into a horny and a mucous layer. Hair-sacs and sebaceous glands are hardly ever present.

The *cutis* of dermoid cysts is said by some authors to be furnished with papillæ; this is denied by others; in any case, however, they do not seem to occur with the same regularity as in the skin. On the other hand, the *panniculus adiposus* is always present; it forms the link between the dermoid cyst and the connective tissue round it.

Among their accidental constituents, *teeth* deserve a foremost place. These are sometimes developed on the surface of the cutis in enormous numbers. They are not always typical enough in form to allow of their being recognised as molars, canines or incisors; but there is never any doubt as to their being real teeth, with fangs, necks and crowns, with enamel, cementum and dentine complete. They are sometimes planted in bony sockets. Again, true *bones* have occasionally been met with in the cyst-wall; bones furnished with periosteum and vessels, just like the bones of the skeleton. *Henle* found in a dermoid cyst, a horse-shoe-shaped bone 1″ in length, furnished with pointed processes, with which wedge-shaped bodies as large as a hemp-seed were articulated by loose capsular ligaments.

The more highly organised tissues, *nerve* and *muscle*, are rare in dermoid cysts. Still they have repeatedly been met with.

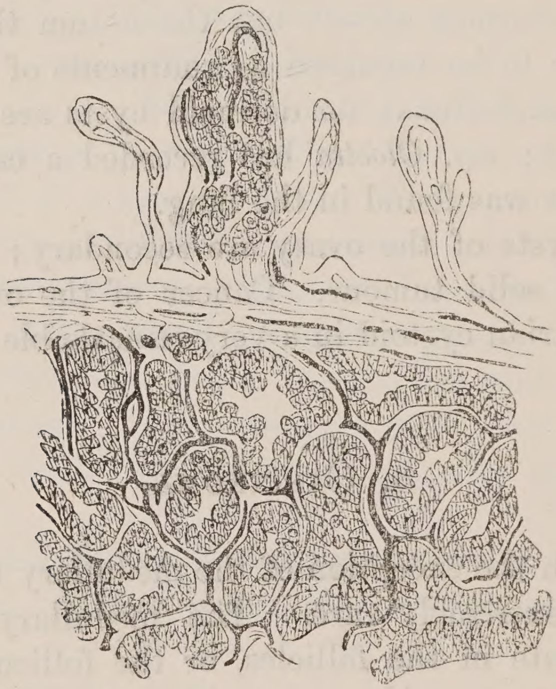
Dermoid cysts are most common (three-fifths of the total number of cases) in the ovary; next in order of frequency comes the testicle. It may be that the peculiar nature of the ovary and testis, as generative glands, predisposes them to the production of dermoid cysts; but the notion that these cysts ought therefore to be regarded as rudiments of fœtal development, is quite gratuitous; for dermoid cysts are also met with in other organs; *e.g. Cloetta* has recorded a case in which a dermoid tumour was found in the lung.

All other cysts of the ovary are secondary; due *e.g.* to the softening of a solid tumour. Cancer of the ovary, however, may mimic ovarian cystoid in a very remarkable degree.

3. CARCINOMA.

§ 586. With the exception of the medullary form, cancer of the ovary is extremely rare. The medullary variety may possibly originate in the follicles, or the follicular rudiments, though confirmatory evidence on this point is wanting. The exquisitely adenoid, or to speak more prudently, "regularly alveolar," structure of the spheroidal nodules of which the tumour is made up, supports the above view of its origin. Fig. 163 represents the edge of a cancerous nodule about as big as a hen's egg. The vessels are filled with blue injection. The nodule is immediately beneath the thickened albuginea, which is itself studded with a number of papillary outgrowths. On examining the substance of the nodule, we cannot but admit its resemblance to the section of a tubular gland, *e.g.* of the renal cortex; the trabecular septa of the cancer-stroma all contain vessels; the cancer-cells clothe them like a sub-columnar epithelium, interstices resembling the ducts of a gland being left in the middle of the alveoli. The albuginea itself contains no cancer-nests, but forms a dense partition between the nodule on the one side, and the papillæ on the other. All the more striking, and in a certain sense conclusive, is the circumstance that one of these papillæ presents, in its rather swollen body, a distinct rudiment of fresh cancer-growth. Elongated fissures, running parallel with, rather than along the vessels, are filled with the same large epithelial cells, which we recognise as cancer-cells in the mature nodule. To me it appears that the lymphatics, here as in the case of tubercle (§ 115), take the initiative in the developmental process, by the proliferation of their endothelia, which then become cancer-cells. An outgrowth of the follicular epithelia, which may possibly exist, cannot be admitted to occur, owing to the papillæ being separated from the nodules in the ovarian parenchyma by a broad barrier of connective tissue. If, therefore, we include ovarian cancer among the glandular carcinomata, we must at any rate concede that it is capable of producing nodules in the connective tissue and its interstices as well, when once it has transgressed the limits of the organ.

Fig. 163.



Glandular cancer of the ovary. Its peritoneal covering, thickened and beset with papillæ, exhibits carcinosis beginning in one of these papillæ. $\frac{1}{300}$.

X.—MORBID ANATOMY OF THE TESTICLE.

1. Inflammation.

§ 587. Acute inflammation of the testicle (I refer chiefly to the gonorrhœal and traumatic forms) begins with an intense serous infiltration of its parenchyma, constantly associated with a moderate amount of exudation into the sac of the *tunica vaginalis propria.* The number of lymphatic spaces in the testicle, their width and distensibility, may have something to do with this; for the appearances are very like those which may be artificially produced by ligature of the lymphatics in the spermatic cord. It is only some of the issues of acute inflammation which present any histological interest. Of course the commonest termination is a complete return to the healthy state; induration is less common, suppuration decidedly rare. The two latter set out from the walls of the lymphatics. In the indurative form of orchitis, an overgrowth of the connective-tissue layer narrows the calibre of the lymphatics, while thickening the *tunicæ propriæ* of the seminiferous tubes by apposition from without, and so obstructing the tubes and interfering with the seminal epithelia. The complete obliteration of the latter elements, with a consequent shrinking and flattening of the entire organ, is therefore the usual end of indurative orchitis. The course of suppuration is very different. The pus-corpuscles separate from the inner surface of the lymphatics, and find themselves forthwith in a free space, occupied by a fluid which is still in active circulation. Should the pus-formation be moderate in degree, the resulting corpuscles are conveyed into the blood-vessels as fast as they are produced; the whole process differing perhaps only in degree from that perfectly normal phenomenon which is known as the "transit of lymph-corpuscles" from the rootlets of the lymphatic system to the blood. Seldom, therefore, do we find pus collected into abscesses; even when accumulation has occurred, the chances are still in favour of the reabsorption of the corpuscles, as compared with their discharge by rupture. Should rupture nevertheless occur, the fistulous openings are small in size, and close up very readily; save when a sort of outgrowth of granulation-tissue takes place round the fistulous orifices, a complication more often noticed here than elsewhere, and occasionally leading to the formation of fungoid, quasi-sarcomatous growths, exhibiting the structural characters of proud flesh.

§ 588. The term "chronic inflammation" has rightly been applied by *Förster* to a condition of the testicle which has also been described under the name of "atheroma testis." The organ is very considerably enlarged. The sac of the *tunica vaginalis propria* is obliterated by adhesions; the albuginea has undergone a high degree of fibroid thickening. In the interior of the testicle, a single large cyst (perhaps equal to an orange) and several smaller ones are usually found, all of which are completely filled with a semi-fluid atheromatous pulp. In it are suspended crystals of cholesterin in enormous quantities, oil-globules of all sizes, granule-cells, with here and there some yellow pigment. On washing out its contents, the walls of each cyst appear lined, over a great part of their surface, with a layer of thickly-set and highly vascular granulations, interspersed with islets of tissue impregnated with calcareous matter; these vary from a mere roughening of the surface, which seems coated with a white adherent powder, to the complete incrustation of a continuous portion of the surface, and its conversion into a rigid, calcareous plate, half a line in thickness. A vertical section through the layer of granulations shows highly characteristic appearances; the layer, as a whole, exhibits the ordinary characters of granulation-tissue, from which it differs, at most, only by the somewhat larger size of its corpuscular elements; nevertheless, it does not secrete pus, but granule-cells (spheroids of fatty granules). All stages of fatty metamorphosis may be admirably studied in those cells which form the surface-layer of the granulation, and which, as it seems to me, reach this point by a continuous process of secretion analogous to suppuration. I have never seen the production of true pus on the inner surface of these cysts when closed; it never occurs unless the cavity has been laid open by the surgeon.

The smaller cysts usually furnish us with sufficient data for determining the mode of origin and development of these interesting formations. They are permeated by remnants of the normal tissue of the testicle, in which we can easily recognise vessels of considerable size together with some connective tissue—*i.e.* the remains of what once were interlobular septa. The intermediate cavities present the elongated, conoidal form of the lobules of the testicle, and often contain long shreds of sodden *tunicæ propriæ* amid larger masses of oily *débris*. Broad tracts of very tough, white and glistening connective tissue, scantily furnished with vessels, environ even these smaller cysts, shutting them off from what is left of the relatively healthy parenchyma. The principal cysts, also, are only *lined* with granulation-tissue or calcareous plates; the main bulk of their walls consisting of the same tendinous material, which often forms strata from two to three lines in depth, especially where it passes into the thickened albuginea.

The process, therefore, is one of indurative orchitis and periorchitis, differing from ordinary induration of the testicle, in its not affecting the whole organ uniformly. It begins by causing a hyperplastic thickening of several main septa, thereby strangling large segments of the testicular parenchyma, and forcing them to undergo fatty degeneration. The luxuriant corpuscular proliferation on the surface of the septa, and the immediate degeneration of the secreted elements into fatty *débris*, the retention of the latter, and their consequent conversion into an atheromatous pulp (§ 29)—these are the causes why the segments of parenchyma, when laced off, are transformed into atheromatous cysts, often attaining a very considerable size.

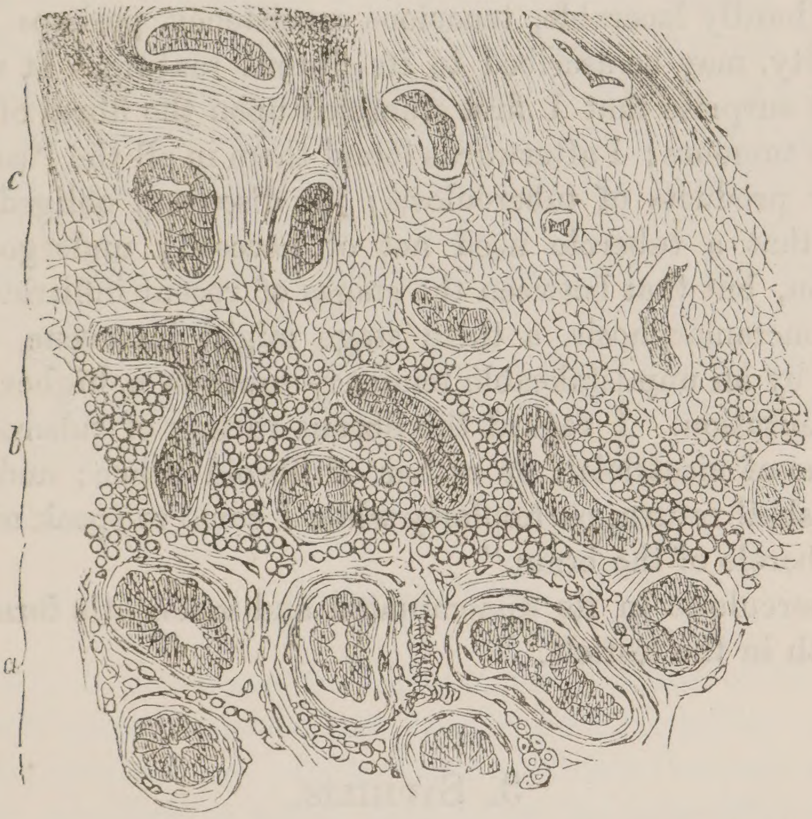
2. TUBERCLE.

§ 589. By "tubercles of the testis" we usually understand certain cheesy nodules of considerable bulk, and more or less globular shape; they are commonly multiple; after a time, they coalesce to form a single mass of very irregular, nodulated or branching form. The cheesy matter is remarkable for its peculiar elasticity, a property which it retains until central softening leads to the formation of an abscess. This tends to burst externally, giving rise to that well-known variety of fistula, which is clinically remarkable for its extreme chronicity, and the occasional discharge of sodden shreds of seminiferous tubuli through it. The epididymis and vas deferens are also liable to this disease; nay, it is especially prone to set out from the parenchyma of the epididymis.

On proceeding to inquire into the origin and extension of this morbid product, we find hardly any opportunity of studying the lesion in its first beginnings; on the other hand, we very frequently—almost invariably—find a textural change going on at the periphery of the nodule, which is obviously connected with its enlargement. The naked eye observes in this region a thin layer of reddish-grey, translucent and somewhat gelatinous material, highly vascular, and bulging a little towards the healthy parenchyma of the organ. In the annexed drawing of a vertical section under a magnifying power of 300 diameters, *a* represents the relatively normal parenchyma of the testis, *b* the proliferating layer, *c* the cheesy nodule. The wholly interstitial character of the process is sufficiently obvious. The tubuli seminiferi remain quite passive. At *a* they are entirely normal; the very thick *tunicæ propriæ* of connective tissue, which play so great a part in cystosarcoma (§ 592), barely show any sign of nuclear or corpuscular proliferation even in their outermost layers. In the zone marked *b* they are being steadily dissociated by the morbid growth, without any sacrifice of their characteristic morphological constituents; in the zone *c* they are still farther apart; here, too, we find the first indications of a glassy swelling of the tunicæ, and a fatty metamorphosis of the epithelial cells. These are the only alterations which occur in the tubuli seminiferi; but even these do not lead to their complete disintegration; for, as has been already observed, the tubuli turn up once more during the softening and discharge of the cheesy matter. We are therefore compelled to assume that they are preserved in the interior of the cheesy mass, as seen in the annexed figure.

Turning our attention to the disease itself, the first point which demands consideration is its seat. It is localised in that very region which, according to the researches of *Ludwig* and *Tomsa*, is permeated by an elaborate system of lymphatic spaces; and if we call in the more recent investigations concerning the development of tubercle to our aid—investigations which tend with such gratifying unanimity to the conclusion that this product, so long enigmatical, is due to a proliferation of the lymphatic endothelia*—then, indeed, we cannot but suspect that the disorder we are now considering is also due to some change in the interior of the lymphatics, differing from that which results in the formation of miliary nodules only by its relatively diffuse character. True, there are no miliary tubercles

FIG. 164.



Section through the border of a "cheesy tubercle" of the testis. *a*. Relatively normal parenchyma; *b*. Infiltration of the intertubular connective tissue with small cells; *c*. Fibroid metamorphosis and caseation. $\frac{1}{300}$.

of the common sort to be found in the present case; but it must be borne in mind—first, that tubercles are known to exist (in the peritoneum) which attain the size of a lentil or even a broad bean, &c.; secondly, that tuberculosis is known to take the very same form which we have here, in other organs also (brain). This latter analogy extends, moreover, to the further metamorphosis of the morbid product. On tracing it from the zone *b* to the zone *c* (fig. 164), we still continue to distinguish the outlines of the cells for a time; but they gradually fade, and the circular cells are replaced by elongated and polygonal, and finally by spindle-shaped forms, which seem to result from mutual flattening; the spindle-shaped elements forming the transition to a purely fibrous texture. The last prevails throughout the cheesy portion of the nodule. Its colour is due to the masses of dark (fatty) granules which are embedded in it; its tough, hardly lacerable, tenacious consistency, perhaps also its durability, may be ascribed to its fibrous texture. It was not without surprise that I first stumbled upon the fibres of *Lebert* in these tumours; I afterwards found them in all the "solitary" nodular products of tuberculosis; the discovery obliged me to admit that a tubercle need not of necessity undergo direct caseation, but that between the stages of recent infiltration and cheesy metamorphosis, a third stage might intervene, characterised by an unmistakeable tendency towards a higher degree of organisation. I regard the fibrous variety of tubercle as an analogue of cicatricial, or rather of fibroid tissue; and to this view I shall return, particularly when I come to speak of "solitary tubercle of the brain."

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* Cf. § 115. Also the more recent researches of *Langhans* and *Klebs*; (*Klebs*: Beiträge zur Geschichte der Tuberkulose. *Virchow's* Archiv, 44.)

Tuberculosis in its disseminated and metastatic form is not met with in the testicle.

3. Syphilis.

§ 590. In the testicle, as in the liver, syphilis manifests itself under two principal forms, one simply inflammatory, the other gummatous. The former gives rise to a well-marked induration, which destroys large tracts of the testicular parenchyma. The mischief sets out from the interstitial tissue; a hyperplastic growth of young connective tissue being followed by its fibroid condensation; even with the naked eye, the white fibrous bands may be distinguished; their shape is conoidal, determined by the lobular segmentation of the organ; the base of each cone lying in the similarly thickened albuginea, while its apex is directed towards the *corpus Highmorianum*, where it blends with the apices of adjoining cones. We ultimately see nothing beyond a continuous mass of white fibroid tissue, in whose interior the tubuli seminiferi, and with them all trace of the old divisions of the gland, have entirely disappeared. The testicle is flattened, the tunica vaginalis propria usually containing serous fluid.

Syphilitic gummata in the testicle usually imply the previous existence of the indurative changes which have just been described. Hence the formation of gummata is to be regarded as only a further specialisation of the morbid process. Several nodules about the size of a cherry-stone are usually scattered through the fibroid mass. A vertical section through the junction of the nodule with the fibroid tissue in which it is embedded, shows most clearly that the specific changes set out from a proliferation of the corpuscular elements of the connective tissue, speedily followed by a fatty degeneration of the newly-formed elements. The masses of fatty granules coalesce, however, without in any way impairing the continuity of the intervening fibrous tissue; and so it comes about that the nodules, like the yellow tubercles for which they may readily be mistaken, are of a very tough consistency.

4. CARCINOMA.

§ 591. It is not easy to distinguish soft cancer of the testicle from soft sarcoma, medullary cancer from medullary sarcoma, with the unaided eye. Both tumours exhibit the same soft consistency, semifluid in parts; both follow the same order of extension from the testicle to the epididymis, vas deferens, and retroperitoneal glands; both are of a milk-white colour. As regards minute structure, *Birch-Hirschfeld* has shown that in soft cancer of the testicle, as in that of the kidney, liver and mammary gland, the cancer-cells are lineally descended from the epithelial elements of the gland-tubuli. The stroma, though abundantly permeated by young cells, is nevertheless marked off from the epithelioid deposits by a sharp boundary-line; the resemblance of the cancer-cells to the normal epithelia of the testicle carries less weight; on the other hand, *Birch-Hirschfeld* succeeded in isolating tubuli seminiferi at the junction of the morbid growth with the healthy portion of the organ, by means of a 15 per cent.

solution of hydrochloric acid; these tubuli exhibited a smooth surface; they were studded with nodular, ill-defined protrusions, or else, expanding somewhat abruptly, they passed continuously into the tumour itself. That these appearances really correspond to the beginnings of the growth, and that these beginnings consist of a proliferation of the epithelial elements of the testicle, is to me, at least, highly probable.

As it grows, cancer of the testicle not unfrequently assumes the character of "fungus hæmatodes." The transition is operated by a very exuberant vascularisation of its stroma, such as I have described in § 156.

Soft cancer is the only form which affects the testicle primarily. The recorded cases of scirrhus of the testicle do not bear the test of our present anatomical analysis; melanotic cancer is said to have been met with as a metastatic deposit.

For the combination of cancer with other tumours, *see* § 593.

5. SARCOMA AND OTHER HISTIOID GROWTHS.

§ 592. Not every tumour which the surgeon summarily dismisses as a "sarcoma of the testicle" is a sarcoma in the stricter sense of pathological histology. The surgeon uses the word sarcoma only to mark the contrast between a firm tumour, "fleshy" in the loosest sense of the word, and one with fluid contents, viz. hydrocele of the tunica vaginalis. The testicle, however, really is a favourite seat of sarcoma in all its principal varieties. And here I may call attention to a very singular circumstance, viz. that when sarcoma affects the testicle, the tumour almost always contains, not only all the chief varieties of sarcoma, but all the histioid formations which are met with in the sarcomata as well. It is in the testicle, more especially, that the intimate correlation of all histioid growths is clearly shown. Cartilage, mucous and adipose tissue, striped and unstriped muscle, enter more or less into the composition of sarcomata of this organ. Both cartilage and muscular tissue may occur as independent and primary tumours; but after the lapse of a short time, they are usually converted into round-cell and spindle-cell sarcomata by a rapid proliferation at their circumference.

These frequent combinations introduce an element of great variety into the structure of sarcomata of the testicle; and this variety is rendered yet more manifold by the very frequent occurrence of cysts in their interior. The number of these cysts varies; as regards size, we can trace all gradations between a poppy-seed and a pigeon's egg; the contents of the smaller ones are gelatinous and viscid; they subsequently become more fluid, and are rendered turbid by the admixture of blood, crystals of cholesterin, and oil-globules. Even in the larger cysts, we often find the contents synovia-like and viscid, while a fluid which is purely watery and serous is absolutely rare. The smaller cysts are always lined with a continuous layer of columnar epithelium; papillary outgrowths are not uncommon; and these may become so numerous as actually to fill up the entire cavity of the cyst (*cystosarcoma phyllodes*). On endeavouring to trace the origin and development of these cysts, which are also met with, though more rarely and always solitary, in cancer of the testicle, we are first of all confronted with the seminiferous tubes, which, when compressed at any point by the interstitial growth, degenerate into retention-cysts immediately behind the point of obstruction. Such at least is the generally received view; I would only add the possibility of a whole plexus of seminiferous tubes—of a circumscribed portion of the testicular parenchyma, becoming dilated at once, and serving as a starting-point for the cystoid change. I have not seldom found cysts of very minute size, traversed by single partitions of sodden connective tissue, which I could not but regard as the remains of former intertubular septa.

§ 593. The following are the most usual of the simple and compound tumours belonging to the histioid series:—

a. The soft or MEDULLARY SARCOMA outwardly resembles the medullary variety of cancer. This resemblance is at its highest in those very common cases where the two growths are actually combined. Such tumours are, in the main, soft spindle-cell sarcomata with broad trabeculæ; the trabeculæ of spindle-cells enclosing, or leaving between them, certain small interstices which contain nests of true cancer-cells. The latter are not unlike seminiferous tubes with their epithelia, seen in transverse section; and the most recent investigations make it probable that they really are derived from seminiferous tubes;

yet the cells are not like ordinary seminal epithelia: they present the suspicious irregularity of outline, the polymorphism, which is peculiar to cancer. Here and there, too, we find the proper cancer-structure in the ascendant, giving the entire growth the aspect of a cancer with a sarcomatous stroma

When the medullary sarcoma is uncomplicated, or combined with cartilage and mucous tissue, we are more likely to find a round-celled parenchyma with a well-developed intercellular network; that type of structure which is known as "lymphadenoid," and which differs from the ordinary round-cell sarcoma by its greater softness, and the number of readily isolable corpuscular elements which may be scraped from its cut surface; this renders it liable to be confounded with soft cancer unless it is subjected to microscopical examination.

All medullary tumours of the testicle are in the highest degree malignant. Should they originate in the testicle itself, and not in the epididymis, the albuginea continues for a long time to resist their growth; should the albuginea itself be destroyed, the growth advances with extreme rapidity along the spermatic cord into the abdomen, involving the retroperitoneal glands, &c. So that in a short time the tumour of the testicle itself becomes the least important part of the disease.

b. CYSTOSARCOMA TESTICULI is always a complex tumour. Its most constant feature is a relation of the sarcomatous growth to the seminal tubes, analogous to that which was first described by *Billroth* in his "adenoid sarcoma" of the mammary gland. The proliferation is concentrated in the sub-epithelial connective tissue—*i.e.* it presents the appearance of an enormous thickening and round-celled degeneration of the tunica propria. This is complicated on the one hand by dilatation of the ducts, on the other by phyllodic proliferation in their interior (Cf. § 605). *Förster*, indeed, describes sprout-like protrusions of the tubuli seminiferi, such as are generally confined to the various species of cancer; for my own part, I am rather inclined to interpret the appearances he figures, as due to puckering of the walls of the dilated ducts. Such folds, when cut across, are very like epithelial protrusions. Here and there, we notice cysts without any papillæ on their walls. Yellowish-brown globular concretions, which are peculiar to the generative glands, are suspended in the fluid contents of the cysts.

These changes in the seminiferous tubes are associated with histioid proliferation between them. Here we find little deposits of hyaline cartilage; their peculiar beaded and occasionally branching form reminds us that (as was noticed by *Paget* and *Billroth*) they correspond to the course of the lymphatics, whose canal they occupy. Larger deposits of mucous tissue, nay, even muscular and adipose tissue, have sometimes been found embedded in the interstitial formation. Finally, cancerous metamorphosis, which is always imminent, must also be taken into account; for the glandular and other organs of generation are generally far more prone than other parts to exhibit a transition of simple inflammatory irritations, of ulcers, operation-wounds, catarrhal overgrowths (hyperplasiæ), into sarcomatous, and ultimately into cancerous degenerations. The longer a formative irritation persists at any point in the generative system—as *e.g.* the external os—the more marked does the tendency towards luxuriant proliferation, and finally to carcinosis, become.

c. ENCHONDROMA in the testicle takes the form of a solitary, hyaline nodule, varying in size from a walnut to a hen's egg. After it has lasted for some time, perhaps for years, as a painless, sharply circumscribed, hard lump, a rapid enlargement, usually attended by pain, sets in; on dissecting the testicle after it is excised, we find the cartilaginous nodule embedded in a mass of sarcomatous tissue, whose growth is usually found to be especially exuberant in some one direction, where it has established sarcomatous nodules of large size in the neighbourhood of the old enchondroma.

d. MYOMA of the testicle is solitary. *Rokitanski* has described a specimen as big as a goose's egg; it consisted of striped muscle. I myself had a tumour sent me by *Middeldorpf* in the year 1860, which was made up of unstriped muscle with numerous nerve-fibres. The latter formed plexuses which sent many twigs into the muscular substance. The individual fibres were bent hither and thither in zigzags. The inadequate methods of research then at our disposal prevented me from tracing their course more thoroughly.

6. ATROPHY.

§ 594. Apart from the secondary atrophy of the seminiferous ducts which is due to inflammation and tumours, I need only refer to the premature occurrence of senile involution. As we all know, the physiological functions of the testicle cease after the age of 60. The spermatic epithelia gradually succumb to a fatty degeneration. The entire testicle grows proportionately smaller; it becomes soft, and exhibits on section a yellowish, dark butter-yellow, or even brownish hue.

XI.—MORBID ANATOMY OF THE MAMMARY GLAND.

1. INFLAMMATION.

§ 595. The tumours of the female breast have been so early and so often subjected to active histological investigation, that the mammary gland may not inaptly be termed the foster-mother of pathological histology. Our nearly total ignorance of the histology of mastitis is all the more singular. We must content ourselves provisionally, with transferring what direct knowledge we possess concerning other glands of analogous structure, *e.g.* the salivary glands, to the mamma; thereby elucidating the coarser phenomena of mastitis.

The acute inflammations which occur during lactation are either diffuse—involving the entire gland—or circumscribed—forming nodules from the size of a pigeon's egg upwards. Certain diffuse forms of inflammation, which we include under the head of mastitis, run their course, not in the gland itself, but in the lax connective tissue which surrounds it both in front and behind. These very commonly lead to abscess; and as regards their histology, come simply under the head of *phlegmon telæ cellulosæ* (§ 94). As regards the nodular foci of inflammation, we may also consider the interstitial tissue as the primary seat of mischief. The retention of milk in the efferent ducts of the affected lobules, when it really occurs, may be very simply explained by the inflammatory infiltration of the surrounding connective tissue, in the manner already adopted for the pathology of retention-cysts in general (§ 70). The nodule usually suppurates at several points at once; some day, perhaps, we may succeed in tracing the beginnings of the suppurative liquefaction to the individual lobules of the gland. Positive observations concerning the share taken in the process by the secreting parenchyma are wanting.

The textural features of those painless indurations which often persist for years together as nodules from the size of a walnut downwards, and which ultimately degenerate, or soften, or pass into sarcomatous or cancerous growths, are environed by still greater obscurity than even those of acute mastitis. The case is probably one of plastic, corpuscular infiltration of the connective tissue, which, as we know, constitutes a neutral, prodromal stage of the majority of morbid growths.

2. TUMOURS.

§ 596. At the outset of my observations, I alluded to the fact that pathological histology might be said in some sort to have got its training in the investigation of tumours of the mammary gland; and this might lead the reader to expect an exceptionally scholastic treatment of the subject in the following sections. He will find himself disappointed, if by a scholastic exposition he understands a sharply-defined and systematic classification, a series of well-characterised divisions, and a minute analytical subordination of the subject-matter. The progressive specialisation of our studies has resulted rather in the obliteration of old land-marks than in the erection of new ones. For my own part, I know of only two great categories of mammary tumours; the first including those which originate in the epithelial elements of the gland; the second comprising such growths as spring from the subepithelial or interstitial tissue. Both these groups may encroach secondarily upon each other's territory; all the more must we insist upon their place of origin as the true source of all their subsequent peculiarities.

a. Tumours which spring from the Epithelial Elements of the Gland.

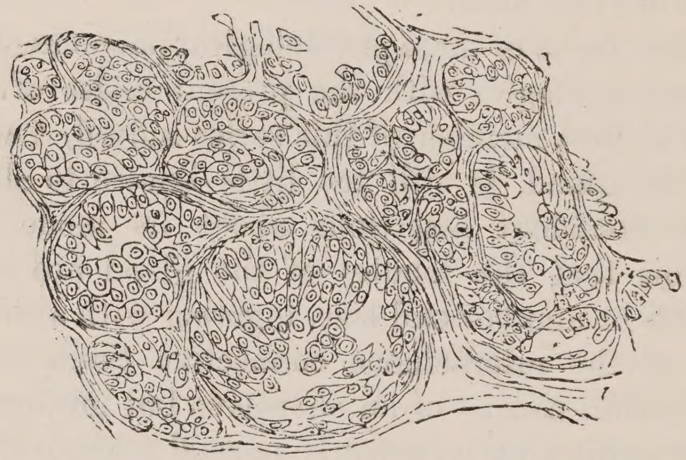
§ 597. All the morbid formations which come under this head have one great feature in common; an increased prominence, a more vehement expansion of the epithelium which lines the acini. This, as we know from normal histology, consists of a single layer of small, low, nucleated cells, in the closest contact with their opposite neighbours, and exerting a moderate degree of lateral pressure on one another. During lactation, the number of cells is doubled or even trebled; the new-comers, however, are not piled up on one another, but squeeze in between the former elements, so that of course the superficial extent of the epithelium, and with it the circumference of the terminal follicles of the acinus, are markedly augmented. The periacinous and interacinous connective tissue, becoming more succulent and richer in migratory elements, gives way before this active expansion of the acini; the terminal follicles of each acinus soon come into close contact with one another, remaining separated only by a very narrow partition, which is, however, persistent. The utmost possible degree of distension is at last attained. What epithelial elements are subsequently developed can only find room on condition that the older cells separate from the wall of the acinus; these pass into its central cavity, where they undergo fatty metamorphosis, producing a large amount of oily *débris*, which we call milk.

§ 598. The course of these physiological phenomena furnishes many welcome analogies with the present series of mammary tumours. The first member of this series indeed, TRUE HYPERTROPHY of the gland, is still too little known to allow of our making any confident assertions about its mode of origin. *Birkett* affirms that the lobules of the gland are abnormally increased both in number and size, together with a simultaneous overgrowth of the interacinous connective tissue. This rare disease would thus consist of an enormous but uniform swelling of the breast, exhibiting a perfectly normal texture throughout.

§ 599. Equally rare, though it has been carefully studied, is a tumour which, in accordance with the definitions laid down in §§ 148, 152, I am inclined to call ADENOMA of the breast. The basis of the growth is unquestionably furnished by a proliferation of the epithelial elements of the acinus. It differs, however, from the physiological form of proliferation, by the circumstance that the cells are piled on one another; also by the absence of the normal fatty transformation. The young cells are derived from the extreme edge of the connective tissue (fig. 165); at this point we notice very small cells, closely adherent to the wall of the follicle, and seemingly furnished by a very thin layer of nucleated protoplasm which lines the whole of the alveolus. The young cells gradually emerge from this layer and intrude between the bases of the deepest epithelial elements. These elements themselves are gradually detached, and pushed towards the alveolar cavity;

layer after layer is thus produced, until at last the masses of epithelium formed on every side meet in the centre of the cavity, which is thus obliterated. A progressive dilatation of the cavities then sets in, precisely analogous to that which occurs physiologically in connexion with lactation, but differing from it most essentially in not occurring uniformly throughout all parts of the gland-substance. On the contrary, isolated follicles expand at the expense of the rest, and an acinus which has undergone this form of degeneration soon acquires a very strange appearance, although its true nature may still be easily recognised. Moreover, the gland as a whole is not uniformly affected. On the contrary, the tumour forms nodules which may reach the size of an orange, while the remainder of the gland wastes.

FIG. 165.



Adenoma mammæ. True epithelioma (*Billroth*). For details, see text. $\frac{1}{300}$.

A characteristic feature of the disease is the comparatively high development of the individual cells. This always tends towards the specific type of epidermic evolution; it does not go beyond the production of transitional epithelia and grooved cells which never become horny.

As time goes on, the contiguous cell-nests coalesce more and more; a fatty metamorphosis sets in in the middle of the larger ones, terminating in the formation of atheromatous cysts, which may be scattered through the tumour in considerable numbers, the individual cysts often reaching the size of a pea. Nothing is known of any rupture of these cysts externally, of their ulceration, &c.; so, too, the ulterior fate of patients afflicted with these tumours is very doubtful; no metastasis to the lymphatic glands of the axilla has hitherto been observed.

The above facts oblige us to class this tumour with the glandular cancroids or adenomata; I have no objection to urge against the term "true epithelial glandular cancer" introduced by *Billroth* and *v. Brunn.*

§ 600. We come next to SOFT CANCER of the breast, characterised in its earliest stages by the rapid and simultaneous enlargement of one or more lobules to lumps of considerable size, which give the patient a great deal of pain. The origin of soft cancer from the epithelium is quite as decided as that of the tumour which has just been described. But they differ essentially in the manner of the proliferation. In the former case, we had "extrusion of epithelial cells from the matrix;" in the present one, we have "fission of existing epithelial cells." The absolute sharpness of the limit, which is early established in the present case beween connective tissue and epithelium, is therefore very characteristic. The connective tissue of the stroma is marked off by a smooth, wavy boundary, whose outer edge is hyaline and translucent. It runs exactly parallel to the surface of the epithelial cylinders, without uniting with them at any point. We see at once that the proliferation and independent growth of the epithelium is the chief determining cause of whatever alterations are produced. The epithelium first produces a solid cord which fills the acinus as far as its terminal follicles. The cells at the same time take on the character described in § 154, *sc.* that of large, very protoplasmic cancer-cells. In the youngest of these elements, the protoplasm of each single cell seems to run into that of its neighbours. Soon, however, a distinct segmentation takes place, followed by the polymorphism due to the mutual pressure of the growing cells.

Constriction and fission of nuclei are everywhere apparent. Next, the epithelial cylinders begin to grow outwards and to intrude into the connective tissue, which gives way before them. The interalveolar septa are broken down; in a short time the thick partitions which permeate the acinus are converted into a delicate and wide-meshed network, which sustains the vessels. Meanwhile, the thicker masses of connective tissue which separate the individual acini of the affected lobe, are abundantly infiltrated with small round-cells. The connective tissue is thereby made softer and more yielding; its capacity for taking part in the growth of the cancer is increased. The cancerous nodule has by this time assumed the form of a very large tumour, in which, however, all parts of the former lobule, much as they may be altered, can still be recognised. But now its development enters on a new phase.

This is characterised by the appearance of fresh nodules in ever-increasing numbers in that part of the gland which is still intact. The fresh nodules grow just like the old ones, with which they partially coalesce, contributing in this way to form a large, irregularly tuberculated and soft tumour, over which the skin is tightly stretched; ultimately undergoing suppurative disintegration, and exposing the cancer to the air.

§ 601. Some excellent researches of *Köster's* have lately made us acquainted with a new way in which cancers may originate and grow. I allude to their origin from the endothelia of the lymphatics, which renders the extension of the epithelial cylinders into the lymphatic vessels of the adjacent connective tissue possible, and at the same time explains it. Now there is a form of mammary cancer which, setting out from a moderate proliferation and change of type of the alveolar epithelia, passes straightway into an infiltration of the interacinous and interlobular lymphatic network. In a very tough nodule of moderate size, which looks more white than grey to the unaided eye, the microscope shows that the terminal follicles of the acini, and the efferent canals as far as the larger galactophorous ducts, are dilated and filled with fatty-granular *débris*, with granule-cells and epithelial elements; to these nests and cylinders, which, as already stated, are distinctly recognisable as the constituent elements of former acini, the infiltrated lymphatics adhere by a slightly-expanded base. The lymphatic network is as completely filled with cancer-cells as it is with fluid after a successful injection. The arcuate contours, the varicosity, the broad nodal points of the network, are all very plain, and leave no doubt that we really have degenerated lymphatics before us. *Billroth* has aptly termed this variety a TUBULAR CARCINOMA. Yet I cannot consent to draw any sharp line between tubular carcinomata and ordinary scirrhus; my reasons will be clear enough from the following considerations.

§ 602. By far the most usual variety of cancerous disease, HARD CANCER of the breast, in the widest sense of the term, depends less upon a "proliferation" of the existing glandular epithelia, than upon an "epithelial infection," which spreads from them to the connective-tissue corpuscles and lymphatic epithelia in their neighbourhood. The proliferation of the glandular epithelia is usually limited to a moderate increase in the number of the cells, due to fission; the cells then taking the character of cancer-cells and uniting to form a solid mass, which soon ceases to be distinguishable from the nests of cancer-cells springing up in its neighbourhood. Inconspicuous as is this metamorphosis, there cannot I think be any doubt, that it gives the first impulse to all the changes which ensue; in large sections, which embrace the most various stages of the process, the cancerous infiltration may distinctly be seen to set out from the immediate neighbourhood of the acini, and to spread from this point in concentric circles. Its extension, and consequently the actual growth of the tumour, is due to a direct conversion of the connective-tissue corpuscles and lymphatic endothelia into cancer-cells, arranged in nests and bands.

It is assuredly of importance that we should, as anatomists, distinguish clearly between the various constituents of the nutritive apparatus, *sc.* the blood-vessels, the lymphatics, and the intermediate system of "lacunar interstices in the connective tissue;" for nature herself furnishes us with trustworthy criteria for the purpose. We may perhaps find that these elements exhibit a certain individuality as regards some pathological alterations. We must not, however, lose sight of their physiological relationship, which has its anatomical mark chiefly in the similarity and equivalence of the corpuscular elements which line the entire system of canals subservient to nutrition. These elements possess both nuclei and protoplasm; the latter, however, in the blood-vessels and lymphatics, is chiefly represented by a thin, homogeneous plate, to whose outer surface (that which is turned *away from* the interior of the vessel), the nucleus is glued by the often very minute residue of soft protoplasm. Even in the juice-corpuscles (Saftzellen), a partial sclerosis of the protoplasm takes place, as is seen more particularly in mucous tissue, in the cornea, in the tissue of the tunica intima of the vessels; but I do not bind myself to push the analogy, at present, into the minor details of structure. The essential unity of all these cells is far more strikingly apparent in pathological proliferations.

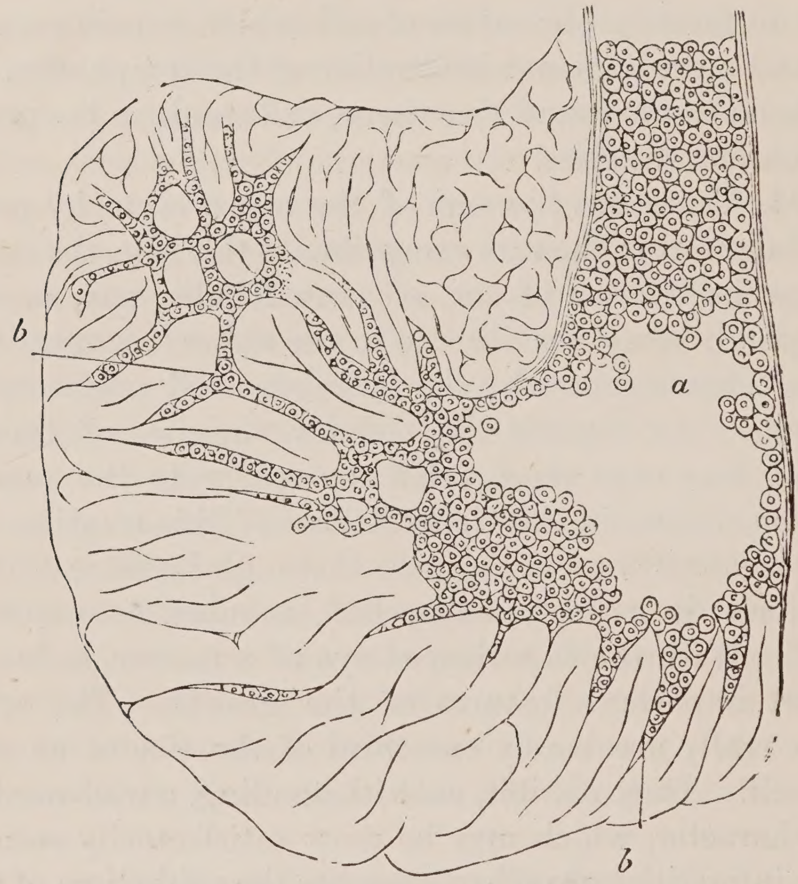
We will confine our attention for the present to hard cancer. The microscopic appearances which it presents have been repeatedly and thoroughly studied; they leave no doubt as to the fact, that the majority of the cell-nests originate by a direct metamorphosis of single connective-tissue corpuscles; so far, at least, *Virchow's* doctrine remains unshaken. True, we erred in generalising too hastily from the results afforded by cancer of the breast; for it turns out that cancer-cells *may* originate otherwise than from connective-tissue corpuscles. All the more triumphantly do the general propositions concerning *Carcinoma simplex* (§ 158, *et seqq.*) maintain their ground in reference to scirrhus of the breast, from which the appended drawings (*l. c.*) were taken. The metamorphosis is ushered in by an "epithelial infection," which is still purely hypothetical, *i.e.* by a stimulus propagated from the actual epithelium to the connective-tissue corpuscles which lie next to it, inciting them to undergo a similar individual evolution. This is followed by the abundant accumulation of protoplasm round the nuclei, their division, the fission of the cells, as already described; and I cannot help even now regarding each of the fusiform, youngest nests of cancer-cells as the offspring of a single connective-tissue corpuscle. Re-examination of the question has convinced me indeed, that the lymphatics may take part in the cancerous production; yet their participation is only prominent in the hardest members of the series, those known κατ’ἐξοχην as "scirrhous;" in the softer varieties, their share does not admit of independent valuation.

§ 603. Accordingly, as the reader will observe, I distinguish between harder and softer forms in a connected series of hard cancers of the breast. The hardness (as contrasted with the soft consistency of medullary cancer), may be ascribed broadly to the fact that the tough bands of interstitial fibrous tissue, though put on the stretch by the cancerous infiltration, and perhaps even to some extent thinned, are never wholly absorbed; so that throughout all the phases of the development of the tumour, they continue to form a rigid, inelastic web, which permeates its substance. The intimate cohesion of the fibres yields only to the irresistible expansile force of *growing* cancer-cells. But when once the cells have passed the zenith of their life, the elastic reaction of the connective tissue reassumes its sway; and I do not think I am over-bold in assuming that this reaction contributes directly to the degeneration of the cancer-cells. The subdivisions of hard cancer flow naturally from the above considerations. The more decided and exuberant the corpuscular proliferation, the larger the size of the individual elements, the more generally the connective-tissue corpuscles are involved in the morbid process, the softer will be the consistency of the tumour as a whole, in harmony with the character of the infiltration; while on the other hand, a moderate proliferation of cells which remain permanently small, and a predominant infiltration of the lymphatics, give the upper hand to the connective tissue, and result in the production of the harder varieties.

§ 604. Cancerous tumours of the breast occur by preference in a nodular form; the rare exceptions to this rule, the occurrence of diffuse infiltration of one or more lobules, nay, even of the entire gland, being usually due to the softer "connective-tissue cancers," characterised by the large size and polymorphism of their cells. As regards the nodular varieties of these latter species, I may once more refer the reader to the remarks on *Carcinoma simplex* in the General Part of this treatise.

True SCIRRHUS merits a more thorough investigation. *Billroth* defines it as a "small-celled, tubular, connective-tissue cancer." With the experienced eye of a master, he has hit the two most important features of the growth. The cells of a scirrhus really are barely one-third of the size of an ordinary cancer-cell. They exhibit, notwithstanding, a well-marked epithelial character, which may be most satisfactorily seen where-ever the interstitial growth approaches the epithelium of the acini and ducts (fig. 166). Equally characteristic of these cells is their great durability. Degenerative changes can hardly be detected in these cancers. The cut surface of the nodule is tough, white, in parts of a silky lustre, and devoid of that yellow marbling which distinguishes the zone of fatty metamorphosis in simple cancer. The second of *Billroth's* criteria, the "tubular" structure, depends primarily upon infiltration of the lymphatics, and secondarily upon the fact that the connective-tissue corpuscles, in undergoing proliferation and change of type, fill the lacunar interstices more uniformly, in long rows, instead of concentrating themselves at particular points and forming nests, as in simple cancer. The annexed figure (fig. 166) is borrowed from *Waldeyer*, who has done good service in pointing out the connexion of the interstitial proliferation with the epithelium of the acini. We see at *b*, as I think, a bit of the infiltrated lymphatic network; though I have since obtained specimens exhibiting the lymphangioid character of certain tubular infiltrations far more distinctly—sometimes, indeed, showing the morbid growth exclusively confined to the lymphatics (Cf. § 601). Here the connective-tissue corpuscles seem to take but little share in the process. But this is decidedly exceptional. To get an idea of the ordinary type of structure, we must imagine all the fine lines which are seen in addition to the infiltrated products, beset with almost continuous rows of cells.

Fig. 166.



Scirrhus mammæ. *a.* Milk-ducts with hyperplastic epithelium. *b.* Lacunar interstices in the connective tissue (lymphatics ?) infiltrated with cells. After *Waldeyer.*

Colloid cancer is also met with, though rarely, in the mammary gland. I have seen it forming a "cancer en cuirasse."

In conclusion, I append a table of synonyms which will prove most acceptable to the beginner, owing to the very voluminous literature which exists on this subject.

Simple hypertrophy of the mammary gland. True adenoma (*Billroth*).

Adenoma or cancroid hypertrophy, according to my nomenclature. True glandular epithelioma of *Billroth*.

Medullary cancer. Soft cancer of the breast. Acinous large-celled glandular cancer of *Billroth*.

Carcinoma simplex (*Förster*). Included with the next variety, under the common name of scirrhus, by practitioners. The most usual form of mammary cancer. Large-celled (?) tubular cancer (*Billroth*). Carcinoma reticulatum of *Müller*.

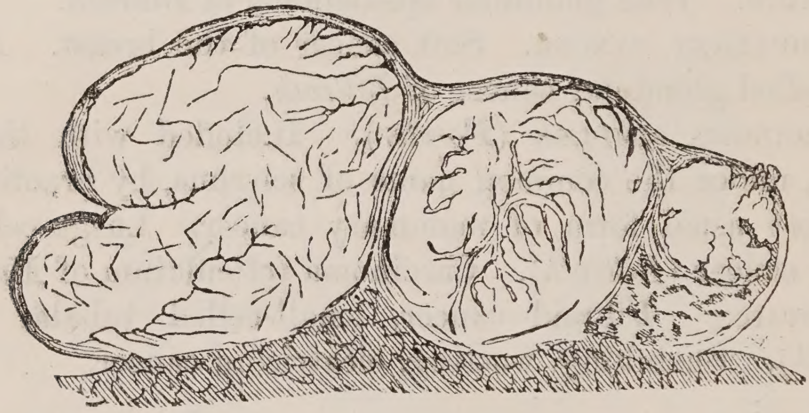
Scirrhus. Fibroid cancer, small-celled tubular cancer (*Billroth*). Shrinking, wasting, cicatrising cancer.

b. Tumours which originate in the Connective Tissue of the Gland.

§ 605. This second group of mammary tumours includes most of the representative forms of histioid growth—sarcoma, fibroma, myxoma, &c., tumours which mostly start from a circumscribed portion of the gland, and, growing in the form of nodules, often reach an enormous size; tumours which, after radical extirpation, seldom recur or give rise to secondary deposits in internal organs. The most important of them is unquestionably the cystosarcoma mammæ, a tumour which deserves our whole attention, because it exhibits the various species of histioid growth, whether singly or in combination, under a form highly characteristic to the naked eye, and affords evidence of the close affinity and intimate correlation which subsists between them.

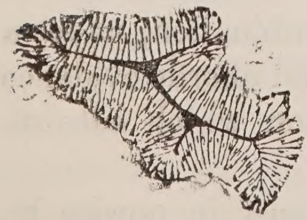
Accordingly the term "cystosarcoma" must in nowise be taken to denote a definite variety, say of round-cell sarcoma, complicated by cysts; it tells us only that a morbid growth, possessing the textural characters of a histioid tumour, has invaded the mammary gland, and given rise to dilatation of its preformed cavities. The way in which this dilatation occurs, however, is so very peculiar, as to give the tumour an exceedingly strange aspect to the naked eye. Round cysts, filled with mucus, are only found occasionally, and in an isolated form. On the other hand, the cut surface of the tumour exhibits a number of shallow fissures, communicating here and there with one another, but for the most part running in parallel or concentric lines, thereby giving the tumour a peculiar, foliated structure, which *Virchow* aptly compares to that of a split cabbage (fig. 167). If we are to speak of "cysts" at all, we must clearly understand that they are either squeezed flat, or so filled with tumour-elements that their cystic character is wholly unrecognisable. Both of these conditions contribute in some degree to the result. It may be regarded as certain that these fissure-like spaces are really the altered ducts. In sections of adequate thinness (fig. 168) we can detect a continuous lining of stratified columnar epithelium, which pours a clear, viscid, synovia-like mucus into the cavity of the fissures. Moreover, the epithelium, as compared with its normal standard, is in a state of exuberant proliferation, which perfectly corresponds to the abnormal extension of the surface which it clothes. But this extension of the surface which supports the epithelium, *i.e.* of the subepithelial and interstitial connective tissue, is the essential factor in the whole process. It is due, either to a uniform

FIG. 167.



Usual aspect of the cut surface of a cystosarcoma mammæ, as seen by the naked eye.

FIG. 168.

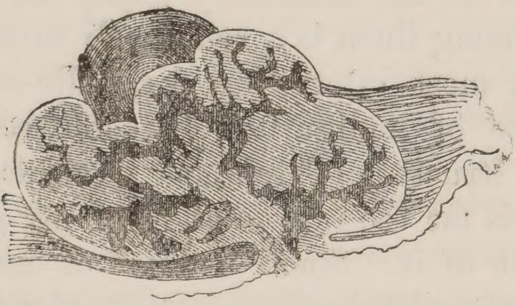


Dilated and distorted milk-duct lined with columnar epithelium. $\frac{1}{200}$.

stretching and thickening of the walls of the ducts, or to an ingrowth of papillose and dendritic vegetations into their interior. More rarely, and for the most part only by way of complication, do solid, globular tumours originate at a distance from the ducts, amid the larger deposits of interstitial tissue. If we add to the resulting variety of external appearances, the manifold variety of the tumour-forming materials, we cannot wonder that nearly every cystosarcoma mammæ should have some special features of its own. We will confine ourselves to the most frequent morphological combinations.

1. *Cystosarcoma fibrosum* (Fibroma intracanaliculare papillare mammæ, *Virchow*). A rounded, usually lobulated enlargement of the mammary gland, of very considerable hardness. On splitting it open, we see some tolerably large nodules (perhaps as large as a hen's egg), presenting the colour and quality of true fibroids, as well as foliated laminæ and septa of the same kind; besides these, we have small and large groups of papillæ which may have broken through the skin here and there, and made their appearance on the surface.

FIG. 169.



Dilated milk-duct, forming a cyst; its cavity is filled with papillose excrescences from its walls. (After *Meckel von Hemsbach.*)

2. *Cystosarcoma mucosum* (Myxoma intracanaliculare arborescens mammæ, *Virchow*. Cystosarcoma proliferum vel phyllodes, *Müller*). This is the most usual form. It differs from the fibrous variety by its more rapid growth and the exuberant proliferation of papillose and foliated excrescences into the ducts. These are best seen when an accumulation of mucoid secretion is associated with the stretching and dislocation of the galactophorous ducts, and globular or hemispherical sacs are formed into which papillose vegetations project (fig. 169). The growth

is made up of mucous tissue, intermingled with round-cell sarcoma-tissue.

3. *Sarcoma pericanaliculare, adenoides* (*Billroth*). A spheroidal nodule which exhibits, on transverse section, the foliated windings of a white or reddish-grey substance; under the microscope this turns out to be either round-cell, or, less frequently, spindle-cell sarcoma-tissue. The growth is limited to the subepithelial layer of connective tissue, and what we see is really a monstrous caricature of the normal ramifications of the glandular parenchyma.

4. *Sarcoma pericanaliculare diffusum.* This is a perfectly uniform and for the most part spindle-celled sarcomatous mass, in whose interior the galactophorous ducts are stretched and distorted into wide, gaping fissures. This growth likewise sets out from the neighbourhood of the ducts, and subsequently extends throughout the interstitial tissue of the gland.

§ 606. Compared with the cystosarcomata, the remaining histioid tumours of the mammary gland are few in number. Most common among them is a round-cell sarcoma made up of several nodules; most interesting, a spindle-cell sarcoma with a limited degree of malignity, characterised by its exquisitely radiating structure (Carcinoma fasciculatum of *Müller*). But the tumour is far too rare to allow of my giving any more complete account of it. Small nodules of enchondroma have repeatedly been met with in the mammary gland; also lipomata, although the latter should always be regarded as altered lobules of the adipose tissue which surrounds the gland.

XII.—MORBID ANATOMY OF THE PROSTATE.

1. Hypertrophy.

§ 607. It has been recently suggested, and the suggestion has met with much support in England (*Thompson*), that the prostate is to be viewed as the homologue of the uterus. The quantity of unstriped muscle contained in its stroma, the circumstance that the recognised equivalent of the womb, the so-called *utriculus prostaticus,* is situated very nearly in the centre of the gland, give this theory some show of likelihood ; but it ought not to be forgotten—1st, that the utricular glands with which the prostatic tubuli would have to be considered homologous, are not embedded in the muscular layer of the womb ; 2ndly, that the *utriculus prostaticus* is not a mere cavity, but possesses a wall of its own which may be distinctly separated from the substance of the prostate, and which would therefore have a prior claim to be regarded as the homologue of the uterus. Nevertheless, it is singular that the most common form of prostatic disease—hypertrophy—should present so unmistakeable a likeness in many of its features, to an equally common disorder of the womb, *sc.* the development of fibromata in its walls.

§ 608. Two forms of prostatic hypertrophy may be distinguished. In the less common variety, we have a uniform enlargement of the organ in all its dimensions and a marked increase in its density, due to the presence of an exceedingly tough, inelastic, whitish, fibrous tissue, which permeates the entire gland. The muscular bundles are all in a state of active overgrowth, while the gland-tubuli waste and disappear. In extreme cases of this form of degeneration, the glandular elements are wholly destroyed ; no trace of them can be detected, and the prostate is converted into a homogeneous fibro-muscular tumour.

Matters take a different course in the second and by far the most usual form of prostatic hypertrophy, which may be recognised at a glance by the presence of discrete nodules in the substance of the gland. These are round, or at any rate rounded in shape; their diameter varies from ·5 to 15 mm.; the smaller ones are invariably soft and of a reddish-grey colour, bulging from the surface when cut across; while the larger ones are for the most part, though not by any means always, of a somewhat harder and more fibrous consistency and a paler hue; they too, however, protrude from the cut surface of the organ. When these nodules are few in number, they appear to be embedded in the prostatic parenchyma; as a rule, however, they are so numerous that the gland seems actually to consist of a sort of mosaic of them, the residual portions of comparatively healthy parenchyma being quite effaced. The manifold varieties of external form presented by the hypertrophied prostate, the implication now of its right, now of its left lateral lobe, and then again of the *portio superior* of the hinder circumference of the gland (the so-called "middle lobe"), the immense variety of distortions and dislocations to which the prostatic part of the urethra may be subjected—all these phenomena are explained by the lack of uniformity in the distribution and rate of growth of the nodules.

§ 609. Let us now proceed to examine more closely into the minute structure and development of this important constituent of the hypertrophied prostate. All the nodules, the smallest as well as the largest, contain both glandular and muscular elements. The former resemble the tubes of the normal prostate both in the sub-columnar (almost pavement) character of their epithelium, and by the manner of their division and ramification, the branches being given off nearly at right angles. I have failed to discover anything like a *tunica propria* in the usual sense of the word; but the fibro-muscular tissue which immediately surrounds the tubuli is stratified in planes parallel to their surface, and may very fairly be regarded as the "proper coat" of the epithelium-lined tube. We should be doing violence to the facts, were we to shut our eyes to the circumstance that the gland-tubuli play the most important part in the entire process; in so far at least as the whole structure of the nodules is based upon their form and mode of ramification. I have not been able to ascertain whether an outgrowth of the glandular epithelium in the form of solid cellular processes does or does not constitute the starting-point of the process; I think it more likely that it is the sub-epithelial tissue which is primarily involved. This grows hyperplastic, and swells from a barely appreciable lamella to a stratum of young tissue varying from ·05 to ·2 mm. in thickness, and entirely made up of spindle-cells. Most authors regard these spindle-cells as muscular, and accordingly designate this growth, like the common fibroid of the uterus, "fibro-muscular." I have my doubts as to the legitimacy of this nomenclature; but I would rather avoid confusing a matter which in itself is simple enough, by a dispute concerning names (§ 128). A single gland-tube with its terminal ramifications attains the form and size of a pin's head, owing to the said increase of the subepithelial stratum; it protrudes as a minute nodule above the level of the remaining parenchyma. The further enlargement of the nodule is due, partly to the implication of adjoining tubuli, partly to the independent outgrowth of the existing fibro-tubular elements of the tumour. The more the latter mode of increase predominates, the more isolated does the nodule become as it grows; it may ultimately surround itself by a proper fibrous capsule.

A summary view of what has been said above, shows us the necessity of calling the ordinary hypertrophy of the prostate a "fibro-muscular overgrowth of the peritubular stroma of single segments of the gland, with a coincident elongation and multiplication of the tubuli themselves." A similar affection has been observed by *Billroth* in the mammary gland, and described under the name of Adenoid Sarcoma (§ 605, 3).

2. INFLAMMATION.

§ 610. The prostate, in its relation to acute inflammatory changes, presents some analogies with the skin. Like the close webbing of the fibrous bundles in the cutis, so here, the great toughness of the stroma hinders the rapid extension of the morbid process. Accordingly we find that acute inflammation in all its stages restricts itself to minute and isolated, though often very numerous foci. Of course I am not referring to suppurations of traumatic origin, whose extension is regulated by the previous solution of continuity, but to those acute parenchymatous swellings, which are rarely protopathic, but originate mostly in the sympathy of the prostate with the remainder of the genito-urinary system, particularly with catarrhal disorders of the urinary passages.

I believe it possible to discriminate two stages in the course of acute inflammation of the prostate. The mischief begins with marked congestion and œdema of the entire organ; this persists throughout the whole of the first stage. Little is known, unfortunately, concerning the minute textural alterations which occur. *Thompson* observed " dots of thickish pus, which were not really minute abscesses, but gland-cysts." Hence the process appears to be localised in the tubuli at an early period. The second stage—one which is generally obviated by the skill of the surgeon—is that of abscess. Pus-corpuscles are abundantly secreted from the inner surface of the gland-tubuli; they mingle with the normal secretion of the gland to form a glutinous, viscid, greenish-yellow fluid, differing in some respects from ordinary pus. The pre-existing cavities become distended; at a later period some of them may coalesce; and we then find the prostate studded with a variable number of abscesses of different sizes. It sometimes happens, though very seldom, that one of the lateral lobes is excavated into a single abscess of larger size. Weeks and months must elapse before the inflammation can reach this point, owing to the resistance offered by the unyielding fibro-muscular stroma of the gland. The abscesses usually burst into the urethra; sometimes, however, they may force their way to the surface, establishing fistulous passages towards the rectum, the bowel or the penis.

3. TUBERCULOSIS.

§ 611. Tuberculosis only affects the prostate in that form which causes phthisis of the gland. The nodules, first grey, then cheesy, are found embedded in the neighbourhood of the tubuli. Their softening and disintegration lead to the formation of numerous abscesses which increase in size by the progressive addition of new tubercles, and finally perforate the bladder. The whole process is analogous to *phthisis renalis* and *testiculi* (§ 569 and § 589).

4. Cancer.

§ 612. Cancer of the prostate is not common, and is always protopathic. The medullary variety forms tuberous growths of large size which usually protrude towards the interior of the urethra, finally perforating it and forming ulcers. *Oscar Wyss* asserts that the disease originates in a primary degeneration of the gland-substance, particularly of the tubular epithelium, while the stroma remains passive. I have no views of my own on the subject. Melanotic cancer, which has also been met with in the prostate, would only be a variety of the medullary form.

XIII.—MORBID ANATOMY OF THE SALIVARY GLANDS.

1. Inflammation.

§ 613. The noteworthy progress which has recently been made in elucidating the normal histology of the salivary glands has not yet made itself felt in the cognate field of morbid anatomy. This is principally due to the rarity of disease in the salivary glands; also to the fact that inflammation of these glands does not come under observation until it has reached far too advanced a stage. Great difficulties have hitherto beset the experimental investigation of these disorders, owing to the insensibility of the salivary glands in the lower animals to traumatic lesions; so that there is some excuse for our acquaintance with the histological details of inflammation of these organs still continuing to repose on a small number of well-observed cases of parotitis (*Virchow* and *C. O. Weber*). I have myself been obliged to rely exclusively on the materials employed by *C. O. Weber*, whose specimens have been carefully preserved in the Pathological Institute of Bonn.

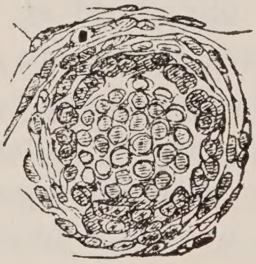
§ 614. It is probable that the inflammatory irritant is always propagated to the salivary gland from that mucous surface upon which its ducts open. Even the so-called "idiopathic" form of parotitis is usually preceded by a stomatitis, however trifling in degree; and as for those cases which are connected with a dyscrasia, the most important among them, that due to mercurial poisoning, has also been proved to depend on an extension of morbid action from the buccal mucous membrane; so that it is only the parotitis associated with zymotic diseases (typhus, pyæmia, acute exanthemata, &c.) which can still, according to our theory, be ascribed to the direct influence of the altered blood which passes through the gland. These *a priori* views concerning the etiology of inflammation of the salivary glands, are fully borne out by the anatomical changes which attend it; for they consist of a catarrhal inflammation of the secreting parenchyma, combined with catarrh of the salivary ducts.

First, then, as regards the parenchyma. *Virchow* deserves the credit of having put aside the earlier, mistaken view, once generally accepted, *sc.* that parotitis was essentially an inflammation of the connective tissue of the gland. True, that in acute parotitis both the capsular connective tissue of the organ, and especially the septa in its interior, undergo a very considerable degree of infiltration, first with serum, at a later period perhaps even with pus. Nevertheless, every inflammation of a salivary gland sets out from the secreting parenchyma in the narrowest sense of the term, *i.e.* from the epithelial elements which line the short terminal follicles of the gland. The so-called lobules, barely appreciable by the unaided eye, and which normally attain the size of a big pin's head at the utmost, and are of a pale yellowish-grey colour, attract our attention in the inflamed gland as tense, swollen bodies, as large as a lentil, and of a dark-red hue. It is obvious that the inflammatory hyperæmia has concentrated itself very specially upon these lobules. Even extravasations may here and there be observed on their surface. If we now proceed to examine hardened specimens under the microscope, we recognise the following appearances (though not till our eye has grown somewhat used to the variety and complexity of the picture).

Groups of the terminal follicles are seen in various stages of morbid change, according as they belong to one or other lobule. Side by side with lobules which are still quite normal, we find—1st, some, whose epithelial elements are much enlarged, darkly-granular, and loosened from their connexion with one another. The swollen cells, which here and there exhibit nuclear fission, fill up the entire available space, which they distend to twice its usual size or even more, according to circumstances; *Weber* has also observed endogenous proliferation of pus-corpuscles in these large cells. 2nd, others, containing a large number of pus-corpuscles in their alveoli, while their walls are still lined by a continuous layer of epithelium (fig. 170). This pus is equivalent to a "catarrhal secretion from an inflamed surface"; we have only to inquire whence it is derived?

Several answers suggest themselves. We might refer to the endogenous proliferation of pus-corpuscles described by *Weber;* or we might think of a migration of young cells from the subepithelial connective tissue. I do not regard the presence of a continuous epithelial stratum as any objection to the migration hypothesis. Thirdly and lastly, it is just possible that the epithelia which still adhere to the alveolar walls have generated the young cells lying in their midst by undergoing fissiparous multiplication. Active fission may often be seen going on; and when we reflect that this same layer of cells is probably the source of the normal epithelia as well, we are involuntarily led to suppose that a quantitative excess of physiological renewal may have some share in the inflammatory process. Even those lobules which are distended with recently swollen epithelia, exhibit nuclear fission in those stellate and anastomosing cells, crescentic in transverse section, and very rich in protoplasm, which form a special layer between the connective tissue of the alveolar wall and the mature salivary cells. According to *Pflüger*, these cells are most intimately connected with the nervous system. The theory that they also provide for the renewal of the superjacent epithelial stratum (a view which has been especially advocated by *Heidenhain*) does not appear incompatible with this. Now if we compare the various altered lobules with one another, we speedily discover that it is just these cells which persist after the remainder of the epithelial stratum is shed, and which simultaneously undergo a morbid process of proliferation. 3rd, lobules in which no trace of

FIG. 170.



Transverse section through a portion of an inflamed parotid. Terminal follicle crammed with pus-corpuscles; its walls are lined with epithelial elements undergoing active proliferation; the surrounding connective tissue is infiltrated with small cells. $\frac{1}{500}$.

epithelium can be detected, and which merely resemble meshes of connective tissue filled with pus. These wholly purulent lobules coalesce to form abscesses of progressively increasing size, which subsequently take the place of entire lobules, nay even of entire lobes of the gland. 4th, the interstitial connective tissue is at first swollen and œdematous; it helps the anatomist to distinguish clearly between the individual lobules which are inflamed. At a later period, a corpuscular infiltration makes its appearance, beginning around the inflamed lobules, and advancing steadily, both inwards, towards the interior of the lobules, and outwards into the broader septa of connective tissue, leading in either case to suppuration and abscess. 5th, the salivary ducts throughout the whole of the inflamed tract also generate pus on their inner surface, as was shown by *C. O. Weber*; yet their epithelium continues unaltered for a long time, and only perishes when the gland has been entirely destroyed by suppuration.

From all this we may infer that inflammation of the salivary glands runs its course more or less as follows:—The first stage is ushered in by hyperæmia of the lobules and cloudy swelling of the salivary cells, with œdema of the connective tissue; in the second stage, a purulent catarrhal secretion is kept up, partly from the epithelial cells of the lobules, partly from the surrounding connective tissue; the development of a corpuscular infiltration of the interstitial connective tissue coincides with this; in a third stage, which, however, is not usually reached, the pus generated by the connective tissue penetrates into the alveoli on the one hand, while on the other it forms abscesses in the connective tissue itself, and so brings about the destruction of the entire organ. The active share in the purulent catarrh, so constantly taken by the salivary ducts, leads us to believe that most of the inflammatory affections of the parotid are really due to an extension of the morbid action from the oral cavity along the efferent ducts of the gland. This would also explain the well-marked catarrhal character of all forms of parotitis.

2. Tumours.

§ 615. Soft cancer of the parotid, a rare disease, seems from all we know of its minute structure, to be a true glandular cancer, *i.e.* it seems to originate in the epithelial lining of the gland itself. An exuberant outgrowth of this layer in the form of solid cylinders of cells which steadily bore their way in all directions, partly breaking down, partly stretching the connective tissue, is the main feature in its development. The stroma consists of thin and smooth trabeculæ of connective tissue, stretched between a network of vessels which is very abundantly developed in parts. The cancer-cells adhere but loosely to the stroma, as a rule; yet an observation made by *Sick* is worth mentioning; he noticed that the cancer-cells adhered more firmly to the veins and venous capillaries, nay even, that they seemed to originate there by proliferation of the corpuscular elements of the adventitia. *C. O. Weber* also insists on a more intimate relation of the connective tissue to the production of the cancer-cells, calling attention to the not uncommon occurrence of papillary outgrowths, intruding into the interior of the acini. I have seen something of the kind myself, in a soft cancer of the mammary gland. The cancer-cells were for the most part very sharply marked off from the connective tissue; but here and there, a continuous transition of connective-tissue corpuscles into cancer-cells could be observed. These appearances coincided, for the most part, with the points of intersection of the thickest trabeculæ of the stroma; but I failed to ascertain anything more concerning their position and significance.

Melanotic cancer is even more rare than the simple medullary form; nothing is known about its textural relations to the elements of the gland.

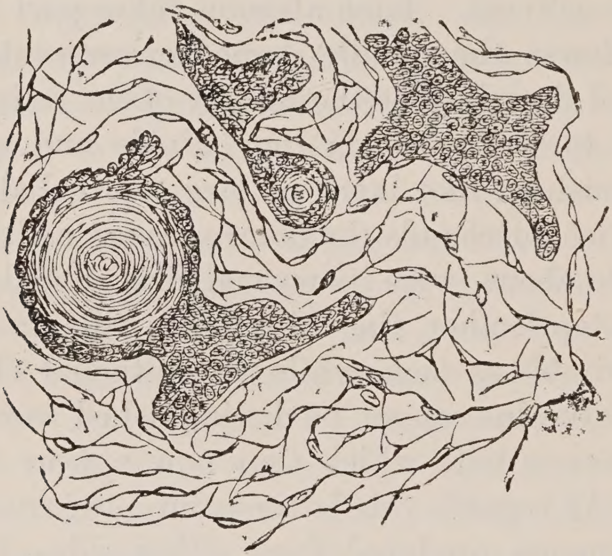
§ 616. *C. O. Weber* has published some statements about Scirrhus of the parotid. They tend to show that this tumour presents striking analogies to scirrhus of the breast; yet the implication of the glandular epithelium is far more decided in the salivary than in the mammary gland; the infiltration of the connective tissue with small cells presenting more of the character of a reactive inflammation and fibroid overgrowth. The glandular epithelia form tubes and cylinders which permeate the tough white mass of the tumour in all directions.

§ 617. No adenoma of the salivary glands has been hitherto described. Epithelioma, too, never occurs in a primary form; yet it not unfrequently intrudes into the submaxillary or parotid, in consequence of the peripheral proliferation of a cancroid growth in the lips or tongue. Here, if anywhere, *Köster's* researches (§ 167) are most strikingly adapted to shed light on this intrusion of the cancroid processes into the structure of an adjacent organ. In exact accordance with the course and mode of division of the lymphatics, we see the cylinders of cells forcing their way, first through the capsular connective tissue, then into the interior of the gland along the broader septa, and finally invading the individual lobules of the secreting parenchyma. Each alveolus takes part in the morbid process as follows: the spindle-shaped or crescentic cells at its edges, which I described as the matrix of the salivary elements, are the first to be involved; they divide and multiply very briskly. A cushion-like layer of large epithelial cells is thus produced, which surrounds the older salivary cells, and distends the alveolus to about twice its normal size. Should the changes have gone a step farther, the old salivary cells cease to be specifically recognisable as such, while the epithelial elements generated in the alveolus cannot be distinguished from those of the cancroid processes with which they now appear to be directly continuous. As regards this latter point—the continuity of the epithelial elements produced from either side—I believe that it is due to an opening-up and expansion of pre-existing prolongations. Nothing can be seen of any other mode of destruction of the glandular elements—say by simple atrophy. I need only add that the connective tissue is enormously infiltrated with small cells; this change everywhere preceding the epithelial proliferation described above, without, however, taking any direct share in it.

§ 618. Besides the carcinomata proper, mention must be made of the frequent occurrence of an epithelial proliferation which only complicates certain compound forms of histioid growth. The salivary glands, as I have said already, are a favourite seat, next to the bones indeed, *the* favourite seat of ENCHONDROMA. Uncomplicated—nay, absolutely pure examples of this tumour, are more often found in these glands than anywhere else. Besides these, however, we find tumours in which the cartilage represents merely the acme of textural evolution, while the main bulk of the growth is made up of mucous tissue with spindle-cell and round-cell sarcoma-tissue (*Billroth*).

These tumours invariably originate in the interstitial connective tissue; they form lumps which may attain the size of a closed fist, but which, on account of their exclusively central growth, usually become intolerable when they have reached the size of a walnut. They very commonly present a radiating structure; a tough, fibrous nucleus, sending out radiating bands of sarcoma-tissue, here and there inlaid with islets of mucous tissue and of cartilage. In other tumours again, the mucous tissue is the dominant constituent; these are accordingly called "myxomata of the parotid." It is this variety that *Billroth* found to be complicated by the epithelial proliferations alluded to above. Whether they set out from the acini of the gland or not, is doubtful; but it is quite certain that their main bulk consists of altered lymphatics. This is obvious from a single glance at *Billroth's* beautiful preparations, one of which is now at my disposal. The entire lymphatic network with its characteristic outlines is seen to be filled with masses of epithelium; and even the little fragment of which I made a drawing before I came across *Köster's* researches, exhibits the unmistakeable contours of three lymphatics cut across transversely and obliquely. It is a singular fact that "pearly nodules" are met with in these cases, though they never occur in secondary cancroid of the salivary glands (§ 617).

FIG. 171.



From the cut surface of a myxoma of the parotid. The spaces filled with epithelial cells and pearly nodules are probably lymphatics. *See* text. $\frac{1}{300}$.

XIV.—MORBID ANATOMY OF THE THYROID BODY.

[The elaborate researches of *R. Virchow* (Krank. Geschw. iii. 1) have exercised so great an influence in elucidating and advancing our knowledge of the morbid anatomy of the thyroid body—which previously laboured under a certain vagueness and uncertainty—that I may venture to handle this rather difficult topic in the summary way which befits a text-book.]

1. GOITRE (STRUMA).

§ 619. The thyroid body is liable to few diseases; and among these, goitre is the most important. It consists in an enlargement of the organ, often very considerable, which occurs everywhere in a sporadic form, but is so common in some mountainous districts, that a healthy thyroid, especially among the female part of the population, is hardly to be met with.

We might easily enumerate a whole series of goitres differing from one another in kind; *e.g.* cystic, vascular, gelatinous, follicular and amyloid goitres; these forms, however, all group themselves round a common centre, the hypertrophic goitre (*Struma hypertrophica*). In other words, every goitre, however singular may be its ultimate differentiation, begins as a true and simple hypertrophy of the gland-substance, which of itself, *i.e.* without the supervention of further, secondary metamorphoses, constitutes what is known as *Struma hypertrophica.* What then do we understand by this term?

§ 620. I will sketch the anatomy of the thyroid gland in a few words. As in the open glands, so here, we distinguish between two elements of structure—1st, the gland-follicles, the analogues of the secreting tissue of other glands, *e.g.* of the tubuli uriniferi of the kidney, of the acini of the mucous glands, &c. 2ndly, a framework of connective tissue which invests the follicles and unites them into little groups or "granules," and into larger aggregates, the lobules and lobes. The follicles are closed sacs, consisting of a simple pavement-epithelium, and containing a single drop of a highly albuminous, clear fluid. The connective tissue carries a very large number of vessels, which derive their supply of blood from the four great thyroid arteries. Now the development of the goitre invariably begins with a proliferation of the follicular cells. Inasmuch, however, as this proliferation is more active at some points of the follicular wall than at others, the follicles come to exhibit protrusions, which, after reaching a certain length, divide and subdivide, become constricted, and form new follicles. *Billroth* succeeded in isolating such branching follicular protrusions entire. The whole process is accordingly a true overgrowth of the gland-substance proper, and so long as it keeps within these limits we call it hypertrophic goitre (*Struma hypertrophica*).

The outward aspect of a hypertrophic goitre depends primarily on the fact that the gland is seldom uniformly affected by the hyperplastic change; single lobes and lobules, or even certain accessory lobules which present themselves at various points of its periphery, being predominantly affected. In this way there arise sharply-defined, round nodules, which bulge outwards when the organ is cut across (goitrous nodules), and which, when situated at the circumference of the gland, give rise to the most striking alterations in its form.

Further distinctions are based on the relative share taken in the hyperplastic process by the connective tissue and the vessels respectively. A very common form of goitre is due to the development of the stroma lagging far behind that of the follicles. This gives the goitrous nodules a very soft, almost fluctuating consistency; they are yellowish-grey in colour, with a slight dash of red, and are separated from the surrounding textures by a dense layer of connective tissue, a so-called capsule, from which they may be more or less readily shelled out (*Struma mollis*). In other cases again, the development of the vessels, and particularly of the arteries and capillaries, outstrips that of the remaining elements; and this to such an extent as to justify the term *Struma aneurysmatica*, first employed by *Philipp von Walther*. The arteries, down to their finest ramifications, are dilated, thickened and tortuous; the tumour pulsates, and its elevated temperature affords additional evidence of the enormous quantity of blood which flows through the gland in a given time. A third modification of the hypertrophic goitre is due to the predominant implication of the connective tissue in the hyperplastic process. Broad white septa of connective tissue permeate the entire organ; tough, fibroid deposits are produced in the interior of the nodules; these extend at their periphery, and fairly choke down the follicular proliferation. Here and there, the nodules and septa come into contact; and finally the connective tissue predominates to such an extent as entirely to mask the overgrowth of the follicular elements, which is always, nevertheless, the primary change (*Struma fibrosa,* Fibroid Goitre).

§ 621. Manifold as are the structural modifications exhibited by hypertrophic goitre in the ascending series of its developmental changes, their number is considerably augmented when we take its subsequent history into account. We come in the first place to colloid goitre (*Struma gelatinosa vel colloides*). We know that even the unenlarged, I will not go so far as to say normal, thyroid contains a certain proportion of colloid matter. We can occasionally squeeze from the cut surface of the gland certain amber-yellow, transparent spheres of a tough and elastic, or perhaps semi-fluid consistency, and we can readily assure ourselves that they originate in the interior of the follicles. Whether they are produced by secretion from the follicular walls, or by a chemical transformation of the albuminous contents of the follicles, is still uncertain; yet the brilliant pleading of *Virchow* cannot but induce many to adopt the latter of these hypotheses. Now this development of colloid matter is especially prone to complicate hyperplastic enlargement of the follicles; hence that familiar variety of goitre which is distinguished by the uniform, often enormous enlargement of the entire gland. The appearance presented by the countless alveoli distended with a yellowish, viscid jelly, and the peculiarly elastic, doughy consistency of the tumour, are highly characteristic.

The more abundant the masses of colloid matter, the more does the mutual pressure of the alveoli cause atrophy of their septa, leading to confluence of the follicles, lobules, and lobes into common cavities of larger size. In these again, the colloid matter grows more and more fluid; it finally becomes as thin as an ordinary solution of albumen, from which, moreover, it ceases to differ chemically. The whole mass is now a cyst, and in proportion to the number and size of the portions of gland-substance which have undergone the above-described metamorphosis, are the size and number of the cysts which the goitre now contains. We find some goitres entirely made up of cysts of various sizes (*Struma cystica*). But the morbid change does not long continue in this stage. What was originally a cyst due to softening, becomes a secreting cyst; hence a new and powerful cause for its further enlargement. Serum, nay even blood, may be poured out in considerable quantity into the cysts; and some of them may attain proportions perfectly colossal (*Riesenkropf*, Giant Goitre). On the other hand, the increase of centrifugal pressure may lead to a further absorption of the septa in the interior of the tumour; the cystic goitre becomes unilocular, and we may ultimately find a single cyst of moderate size, but with exceedingly thick walls, in the place of the thyroid body.

§ 622. We have yet to refer to the amyloid and osseous varieties of goitre (*Struma amyloides et ossea*). Each of these corresponds to a special mode of retrograde metamorphosis, which in the one case affects the glandular parenchyma and the vessels, while in the other it confines its action to the connective tissue of the stroma. As a general rule, it is only single segments of large goitres which become calcified or impregnated with amyloid matter. Yet the deposit of earthy salts may go so far as to enable us to obtain a coherent skeleton by maceration, a cyst-wall converted into a bony drum, &c. On the other hand, the amyloid infiltration of individual nodules of the goitre may attain so high a degree as to result in the formation of a perfectly waxy mass (§ 48); and it is here more especially that the chemist has an opportunity of getting very large quantities of chemically pure amyloid matter for analysis.

2. CANCER.

§ 623. What used to be known as "scirrhus of the thyroid," is nothing more than that fibroid induration of the hypertrophic goitre which has been described above. This leaves soft cancer, which is occasionally met with in the thyroid gland, as the sole representative of the group. When primary, it forms tumours of tolerably large dimensions, which tend to burst into the œsophagus or trachea. Metastatic deposits of cancer are somewhat rare. We have no histological data concerning either the one or the other variety.

XV.—MORBID ANATOMY OF THE SUPRARENAL CAPSULES.

§ 624. It is only within recent years that physicians have come to know and believe in the existence of a series of morbid alterations in the suprarenal capsules. In the year 1855, *Thomas Addison* made the assertion that a constitutional malady, consisting of anæmia and debility going on to fatal marasmus, with a progressive dirty-brown discoloration of the skin, not absolutely uniform, but darker in some patches than in others, was the result of a complete disorganisation of the suprarenal capsules. This assertion has since that time been tolerably well confirmed as a whole; the discoloration of the skin more especially, the *melasma suprarenale*, has obtained civic rights in the realm of science. As regards the causal relation between the symptoms and the structural changes in the suprarenal bodies, authors are still at variance. *Virchow*, who has devoted special attention to the inquiry in Germany, has, on mature consideration, arrived at the conclusion that the disorganisation of the suprarenal capsules involves direct injury to the nervous elements of the capsules themselves, and to those in their immediate neighbourhood (*e.g.* the solar plexus), and that the symptoms must be explained on this basis, *sc.* through the agency of the nervous system. On this view, the precise mode in which the capsules are destroyed would be of little moment. Experience has taught us, however, that in the vast majority of cases, *Addison's* disease is due to TUBERCULOSIS of the suprarenal bodies.

§ 625. Let us then bestow our attention in the first place upon this, by far the commonest affection of the capsules. It begins with an eruption of grey nodules, larger than a millet-seed, in the medullary layer of the organ. We cannot localise them more precisely, whether in the sheaths of the vessels, in those of the nerves, or in the lymphatics. The nodules coalesce to form larger aggregates which may ultimately attain the size of a pigeon's egg and more; these speedily become cheesy. An infiltration of the connective tissue of the septa with small cells, which I regard as inflammatory, takes a great part in this process. Medullary and cortical substance alike succumb to the degenerative change. The capsule alone resists disorganisation; nay, it is converted by an inflammatory form of reactive overgrowth into a succulent, fibroid lamella, from half a line to two lines in thickness, which encloses the cheesy deposit on all sides. I have often seen it adherent to the adjoining surface of the liver, pancreas, &c., and I am of opinion that the lesions of the nervous plexuses, so strongly insisted upon by *Virchow*, may really be due to this extension of the inflammatory changes to the neighbourhood of the suprarenal capsules.

§ 626. No histological investigations have hitherto been made into SOFT CANCER of the suprarenal capsules; this may be primary, though it is usually found in conjunction with cancer of the generative glands. What used to be called sarcoma of the capsules, has recently been described by *Virchow* as GLIOMA. *Virchow* is convinced that the medullary substance of the suprarenal bodies, so abundantly provided with nerve-fibres and ganglion-cells, cannot be devoid of the connective substance of nerve-tissue—of neuroglia; hence he regards certain, not very uncommon, roundish tumours of the medullary substance, varying in size from a pea to a cherry, rose-coloured and tough, as partial overgrowths of this neuroglia—as "gliomata." (Cf. Tumours of the Nervous System.) These must be carefully distinguished from another, more uniform overgrowth of the entire substance of the gland, which *Virchow* has recently described under the name of SUPRARENAL GOITRE (*Struma suprarenalis*). The term is a happy one, owing to the close resemblance of the cortical substance of the suprarenal bodies to the structure of the thyroid gland. In either case we have closed follicles, filled with epithelial cells; in the outermost layer of the cortex, the follicles are spherical; farther inwards, they become elongated and tubular; at the edge of the medullary substance they are very small, and their contained cells are full of black and brown pigment-granules (intermediate pigmentary layer of *Virchow*). *Struma suprarenalis* originates in a proliferation of the follicular elements, and according as this process extends throughout the entire gland, or remains confined to single portions of it, we get either nodular or more uniform enlargements of the organ. The nodules may reach the size of a walnut, when they exhibit elongated, branching and contorted follicles, filled with corpuscular protoplasm in course of fatty disintegration. Wherever the interstitial tissue takes a more active part in the hyperplastic process, tough, fibroid deposits are found. Enough has been said to show that the analogy with goitre certainly goes a long way; we may therefore give in our adhesion to *Virchow's* view with perfect confidence.

XVI.—MORBID ANATOMY OF THE OSSEOUS SYSTEM.

§ 627. The axiom that the phenomena of disease are identical with those of normal life is justly regarded as one of the principal results of scientific investigation in our day. The relation in which the special forms of disease stand towards this axiom was, and still is, different in each individual case. For while the teacher of clinical medicine finds it comparatively easy to persuade his pupils that fever is only a quantitative exaggeration of the normal heat of the body, that the severest dyspnœa results from the very same lack of oxygen and excess of carbonic acid which cause the normal *besoin de respirer*—the task of the morbid anatomist is far more arduous, when he attempts to give even a limited degree of plausibility, *e.g.* to the parallelism between physiological and morbid growth (Cf. §§ 60, 67). Under such circumstances it is especially gratifying to the morbid anatomist, that in the diseases of the bones he has at least one series of phenomena, in which the analogy with physiological prototypes can be so clearly demonstrated as to bring home the doctrine in question to the most unpractised eye and the most prejudiced mind.

Whoever is familiar with the interesting series of textural changes attending the normal growth of bone, with all that is known concerning its development from periosteum and from cartilage—has already mastered the elements of the pathological histology of the osseous system, and is in no risk of losing his way among the minor qualitative deviations from the normal type which nevertheless exist. Many diseases of the bones depend upon a simple excess or deficiency of normal growth; a far larger number on the predominant activity of single anatomical factors, whose part in normal growth is more subordinate; in every case, however, *some* analogy at least may be discovered between the morbid phenomenon and a normal prototype. The above reflections will be kept in mind as much as possible in our partition and classification of the subject.

1. Disorders of Development.

§ 628. I will not pause to inquire whether we are right in ascribing the general excess or deficiency in the size of the body as a whole, the stature of GIANTS and of DWARFS, so exclusively as is usually done, to a greater or less intensity in the growth of the skeleton; I will only call attention to a single fact which bears the other way, viz. that the hypertrophy of single limbs which is occasionally met with, does not depend solely upon an enlargement of the bony framework of the affected part. For if we strip the soft tissues from such a limb, and compare their weight with that of the residual bone, dealing in the same way with the corresponding extremity of the opposite side, we find that the aggregate preponderance on the affected side is not by any means due solely to the bones, but that the muscles, skin, vessels, &c., have undergone a proportionate increase in size and weight.

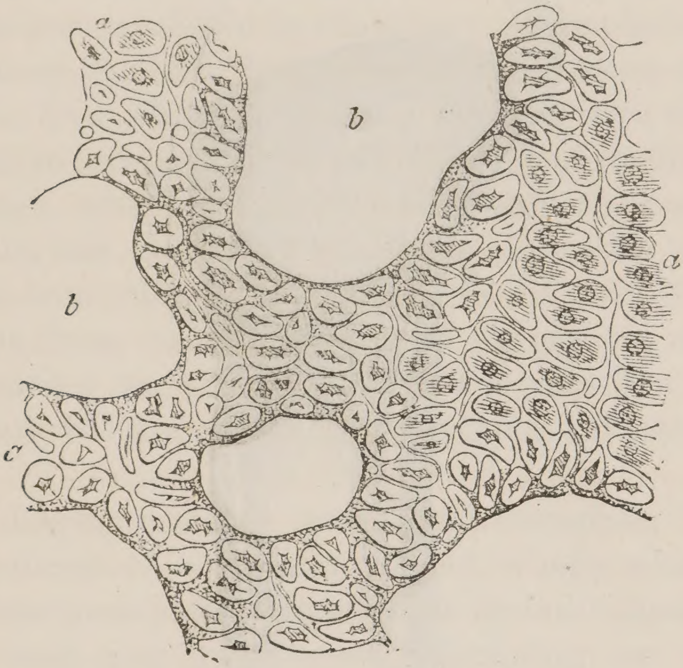
§ 629. A peculiar interference with normal growth is caused by PREMATURE OSSIFICATION OF THE SUTURES AND SYNCHONDROSES. Premature ossification of the longitudinal sutures of the skull gives rise to those peculiarly elongated crania with narrow foreheads, which we term dolicho-cephalic; premature ossification of the coronal and lambdoid sutures causes the brachy-cephalic, globular form of skull. Prognathism results from a premature ossification of the cartilage which originally intervened between the basioccipital and basisphenoid (in the *os tribasilare* of *Virchow*). Early ossification of the pelvic synchondroses gives rise to arrest of development of the corresponding pelvic arch (*synchondrosis sacro-iliaca dextra, sinistra; symphysis*), and consequently to contraction of the transverse and oblique diameters of the pelvis (*P. aequibiliter justo minor—obliquely distorted pelvis*). These changes sometimes attain a pathological significance; they are still, however, so far within the bounds of health that, *inter alia*, the cranial and facial characters of the various races of mankind, exhibit diversities precisely similar to those which have just been described.

§ 630. RICKETS (*Englische Krankheit*). The manifold abnormalities of the osseous system, the long series of distortions and swellings of the bones which occur in rickets, depend ultimately on a morbid acceleration of those changes which usher in and prepare the way for the transformation of cartilage into bone, and the development of bone from periosteum. The actual ossification follows at a slower pace; and hence the substance which, in the normal course of development, undergoes immediate conversion into bone-tissue, and whose existence is therefore of a very brief and temporary character, accumulates in disproportionate quantity. Now it is this intermediate substance which forms the swellings just alluded to, and, moreover, allows the bones to be bent and broken. But I must not anticipate.

§ 631. When bone is developed in a cartilaginous matrix, the latter, as everybody is aware, melts gradually, layer after layer, before the advancing line of bone-tissue, into a relatively soft material, wholly made up of cells; the cartilage-cells divide, and their division is usually repeated twice over, in the cells of the first and second generation, so that each original element comes ultimately to be represented by a group, containing on an average eight corpuscles, which remain provisionally enclosed in a common cavity. This is the former cartilage-cavity. The thick, glassy membrane by which it is lined, is the former cartilage-capsule. Both of these are stretched and dilated, partly by the multiplication of the contained cells, partly by a peculiar expansion which each of the newly-formed cells of the third generation undergoes. The hyaline matrix of the old cartilage is nearly all consumed, so that the large, ovoid capsules of the contiguous groups of cells are in immediate contact with one another. A single, or at most a double layer of such capsules constitutes the normal "zone of proliferation" of the cartilage.

Now it is just these preliminary phenomena, forming, so to say, the preparatory stages in the growth of bone, which are markedly disturbed in rickets. We may fairly assume that in rickets the chemical (?) stimulus which excites the cartilage-cells to undergo division, is present in abnormal quantity, and hence occasions a more frequent fission of the individual elements, as well as a more speedy implication of fresh layers of cells in the proliferative change. The anatomical appearances lend great support to this hypothesis. From ten to twenty or more layers of cartilage-cells are found simultaneously engaged in the process of proliferation. Even the cells of the third generation have undergone division, so that we have groups of from thirty to forty elements, which are arranged in elongated columns, somewhat bent and displaced by mutual pressure, at right angles to the surface of the bone (fig. 172, *a*). Whereas in normal bones the proliferating zone of the cartilage can barely be detected by the naked eye as an extremely narrow reddish-grey stripe, in ricketty bones (fig. 173) it forms a broad, grey and translucent, very soft cushion (*b*) between the cartilage (*a*), on the one hand, and the perfect bone-tissue (*d*) on the other.

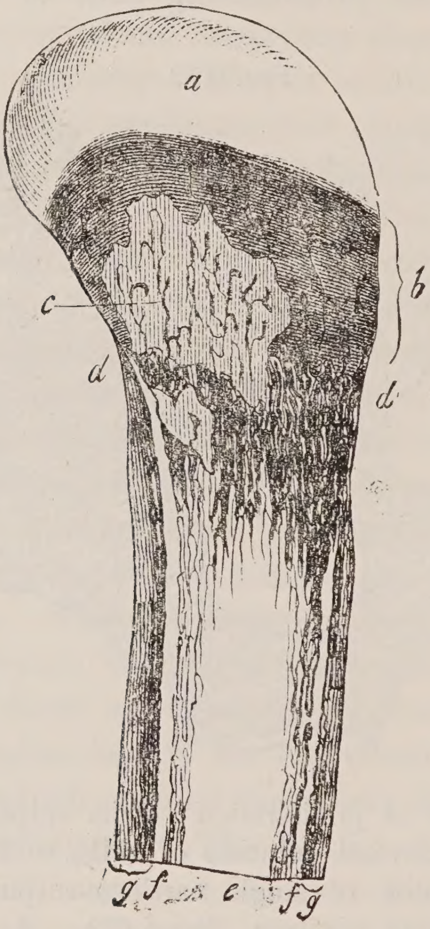
Fig. 172.



Part of the "zone of proliferation" of an epiphysal cartilage in rickets. *a*. Several columns of cells, such as result from the proliferation of single cartilage-corpuscles; *b*. Direct ossification of the cartilage. See § 631. $\frac{1}{500}$.

§ 632. The phenomena we have just traced in cartilage recur in a precisely analogous form in the periosteum. The young and vascular embryonic tissue which is generated by the periosteum on its inner surface, forms under normal conditions only a thin layer which can hardly be perceived by the naked eye. The rapidity with which it undergoes conversion into bone does not allow of its accumulating in any considerable quantity. In rickets the case is different. Under the influence of this disease, the intermediate substance accumulates in layers which are often a line in depth. Older authors speak of a hæmorrhagic exudation between the bone and the periosteum, and compare the deposit, on account of its colour, to the splenic pulp. More careful investigation proves that no extravasation has taken place, but that the red colour of the young connective tissue is due to the number of wide and thin-walled capillaries it contains (fig. 173, *g*). The deposit usually extends over the surface of the bone in the form of broad, flat, uniform elevations. On the cranial bones

FIG. 173.



Vertical section through the upper half of a ricketty humerus. Slightly magnified. *a*. Hyaline cartilage of epiphysis; *b*. Its "zone of proliferation," permeated by medullary spaces; at *c* a large piece of directly ossified cartilage (*see* fig. 174); *d*. The boundary of the bone; *e*. The medullary cavity; *f*. The compact substance; *g*. "Zone of proliferation" of the periosteum.

these are, as a rule, sharply circumscribed, a peculiarity which is not manifested in the same degree upon the bones of the extremities.

§ 633. The next question which suggests itself is this: how does the bone itself respond to this exuberant activity on the part of the cartilage and the periosteum? Does it, so to say, avail itself of the opportunities for a more rapid growth, does it grow faster than usual or no? That it does not usually do this is clear enough from the very fact of the accumulation of the intermediate tissue. The peculiar histological phenomena, however, which are manifested in these very accumulations, spontaneously convey the idea that nature is fully aware of her duty towards the bone, that she is doing her best with the means at her disposal to accomplish the difficult task of ossification; and that although, with her limited resources in the way of earthy salts, vessels, and medullary spaces, she is unable to produce a really solid bone, she yet endeavours, to the best of her power, to distribute these necessary elements throughout the whole of the proliferating zone, as if she wanted to show how far the bone ought actually to have reached, if everything had taken its proper course.

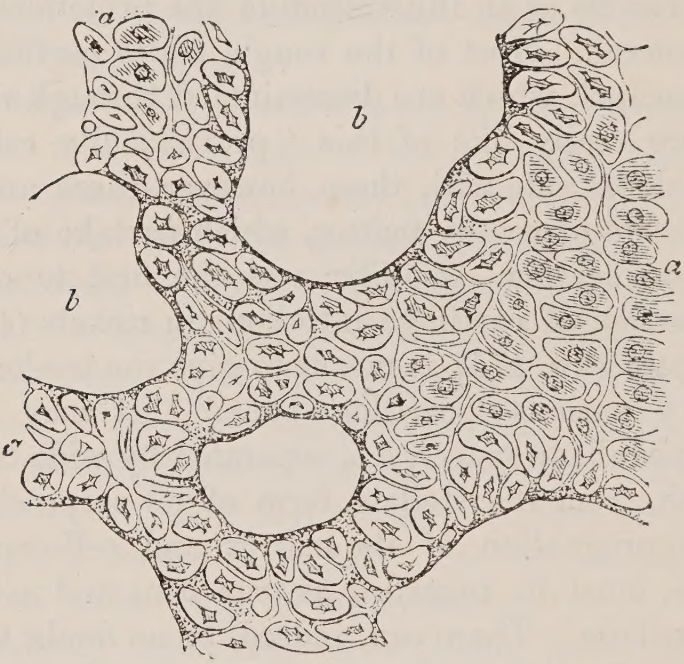
§ 634. Laying aside all teleological metaphor, it is certain that the process of ossification is not wholly absent in the interior of the proliferating zone; that its individual anatomical factors at least may be detected. Confining our attention to the cartilage for the present, we observe in the first place that well-formed MEDULLARY SPACES exist in the layer marked *b* (fig. 173). We know the important part which the formation of medullary spaces plays in the development of bone from cartilage. The spheroidal groups of proliferated cartilage-cells are converted by a renewal of division, which seems to set in very suddenly, into masses of the same size, but consisting of cells which are at once far smaller and far more numerous (medullary cells); a partial liquefaction of the basis-substance enables these masses to coalesce with the nearest medullary spaces of the perfect bone; almost at the same moment, a capillary loop is thrown out into the annexed territory, and a new medullary space with all its attributes is complete. To render this change, which is perfectly unique of its kind, quite plain to the reader's mind, I will define it as an ingrowth of the medullary tissue of the bone into the cartilage. The medullary tissue is exactly like granulation-tissue. Just as the granulations shoot up from the surface of a wound in course of repair, so here, vascular processes of medullary tissue spring from the open medullary spaces at the edge of the bone, and invade the cartilage with their club-shaped extremities. Were it not for our confirmed habit of concentrating our attention, in the present case, upon the formation of cavities to receive the young tissue—upon what may be called the negative aspect of the entire phenomenon—we might just as well term the medullary spaces "medullary papillæ"; and this new way of looking at the matter will perhaps facilitate our comprehension of some of the individual phenomena of the process.

During the normal growth of bone, the development of medullary spaces and the advance of the medullary tissue into the cartilage, take place simultaneously and equably along the whole line of ossification. Between the adjacent medullary spaces, the cartilage undergoes complete liquefaction, the capillary loops inosculate with one another; the development of the first osseous trabeculæ, sclerosis of the basis-substance, transformation of the medullary cells into bone-corpuscles, calcification, &c., set in at the edges of the territories of nutrition (§ 52). One glance at fig. 173 is enough to show that no such uniform advance of the medullary spaces occurs in rickets. On the contrary, we see that while the main body of the medullary spaces remains in line (at *d*), solitary exceptions have pushed their way here and there far into the proliferated cartilage, nay, have even penetrated as far as the boundary of the non-proliferated cartilage (*a*). If we inquire further into the matter, by making a horizontal section through the cartilage at *b* (fig. 17), we find that these sporadic medullary spaces are nevertheless distributed with some regularity, each of them forming the centre of a large territory of cartilage, which depends upon the medullary tissue for its supply of nourishment. So that it seems far from unlikely, and quite in agreement with the general laws of nutrition and vascularisation, that the whole of this antecedent development of medullary spaces is really an effort at vascularisation, intended to supply both the proliferated and the non-proliferated portion of the cartilage with nutriment; the latter of these, more especially, being removed to a disproportionate distance from its source of pabulum, by the interposition of so thick a layer of young non-vascular tissue.

Apart from the development of these medullary spaces, a certain number of calcified patches in the interior of the proliferated cartilage recall the phenomena of normal ossification. In the latter, CALCIFICATION occurs partly as a provisional incrustation of the cartilage at the ossifying border, partly as a definitive impregnation of the basis-substance of the permanent bone. With regard to the former, the provisional calcification of the cartilage, and the curious disturbance which this undergoes in rickets, I need only refer the reader to § 54, where I have taken rickets as an illustration of the principles of calcification in general. Most of the rough, white particles, grating under the scalpel, which are disseminated through the ricketty cartilage, are really bits of this "provisionally calcified cartilage." Side by side with these, however, there are also permanent deposits of earthy matter, which partake of the nature of normal ossification. *Kölliker* was the first to observe the direct conversion of cartilage into bone in rickets (§ 54). The annexed figure (fig. 174) is meant to give the reader some idea of this very curious "cartilage-bone." It may be seen to consist of medullary spaces, *b b*, separated by wide bridges of a tissue, which, from the stellate form of its corpuscles and the complete impregnation of its matrix and cell-capsules with earthy salts, must be regarded as true bone and not merely as calcified cartilage. There can, indeed, be no doubt that besides the impregnation with earthy salts, a very slight change in the position of the individual corpuscles has enabled the proliferated cartilage to transform itself into the tissue in question. At *a a* the latter passes uninterruptedly into the columns of cartilage-cells alluded to above, and the persistence of a special zone to represent the capsule of each cell, notwithstanding the calcification, would be an unheard-of phenomenon in normal bone. On the other hand, the attitude taken up by nature herself towards the cartilage-bone, proves that she means it to be regarded as equivalent to true bone. For as the drawing (fig. 173) shows, the cartilage-bone is quite simply and directly adopted into the structure of the true bone, during the gradual advance of the ossifying border, *d d*. We are able to recognise the sharply-circumscribed bit, *c*, of the proliferated cartilage, as cartilage-bone, owing to its homogeneous, chalky aspect, and the number of its medullary spaces. The section pourtrayed in fig. 174 is taken from this bit. Now if we turn our eyes to the adjoining part of the already completed diaphysis, we notice a smaller patch of precisely similar texture, quite independent of the former one, and quite surrounded by regular medullary spaces. *Virchow* suggests that such residual bits of cartilage-bone may serve in later life as predisposing causes of enchondromatous degeneration.

§ 635. The "incomplete ossification of the intermediate tissue" is a much simpler affair in the case of the PERIOSTEUM. All the complications due to the non-vascular character of cartilage—the development of medullary spaces, the provisional calcification, &c., are entirely absent. The only question is, what amount of true bone is produced from the young and highly-vascular connective tissue. This amount, which probably corresponds to the normal quantity, is distributed, in ricketty bones, over a far larger area than usual; the individual trabeculæ are therefore extremely thin, and the gross result is the conversion of the sub-periosteal "exudation" described in § 632 into a very porous and vascular osteophyte, which forms an unduly thick layer on the surface of the bone, and persists

FIG. 174.



From the "zone of proliferation" of an epiphysal cartilage in rickets (fig. 173, *c*). *a*. Columns of cells not yet ossified; *b*. Medullary spaces of directly ossified cartilage. $\frac{1}{500}$.

moreover, in the osteophytic stage for an unduly long period, while the apposition of compact bone-tissue is wholly arrested meanwhile.

§ 636. We have now traced the rachitic process everywhere to the point at which it culminates. We go on to inquire how the disturbances which it occasions are calculated to cause the various deformities characteristic of the ricketty skeleton. In this connexion we must consider, first of all, that the thick layers of proliferated cartilage which intervene between the epiphyses and the diaphyses of the long bones, yield to the mechanical forces to which the skeleton is everywhere exposed, bulging out laterally, and producing rounded swellings which environ the bone on every side.

The name "Zwiewuchs," given to rickets in some parts of Germany, is based on the mistaken notion that the bilateral protrusion of the swollen epiphysal cartilage of a single joint is really due to the presence of *two* joints lying side by side (*articuli duplicati*). The beaded enlargements of the costal cartilages at their junction with the ribs, are known as the "ricketty rosary." Moreover, displacements of the bone upon the cartilage may occur. The well-known "pigeon-breast" (*pectus gallinaceum*) is due to a recession of the sternal ends of all the bony ribs in consequence of the respiratory movements, while the sternum, together with the costal cartilages, is pushed forward beyond the level of the thorax. For this it is necessary that the costal cartilages should be bent nearly at right angles; and this is only rendered possible by the great flexibility of the proliferated cartilage. Still more important for the physician are the pelvic distortions resulting from an abnormal mobility of the sacro-iliac synchondroses. For inasmuch as the sacrum is naturally pressed down by the entire weight of the trunk, head and upper extremities, and as this downward tendency is inadequately resisted by the yielding sacro-iliac synchondroses, the promontory is more or less deeply depressed into the upper opening of the pelvis, narrowing its cavity from above and behind to such an extent that the subsequent fixation of the abnormal state results in a reniform configuration of the pelvic inlet.

The disturbance of periosteal growth is chiefly to blame for the manifold curvatures and infractions to which the bones of the extremities are exposed. It may seem strange, at first sight, that a deposit of new matter upon the surface of the bones should not rather contribute to make them firmer. That it ought to do so is indisputable. But we must recollect that the increased thickness of the bone, the progressive apposition of new layers of compact tissue to its outer surface, is always accompanied by a simultaneous absorption of compact substance from its inner surface, from that which faces the medullary cavity—an absorption exactly proportionate to the apposition ; and this goes on as usual in rickets. We have already seen that this disorder interrupts the peripheral apposition of compact bone-tissue; the gross result must therefore be a diminution in the thickness of the cortical layer of the bone; and the effects of this cannot be neutralised by the osteophytic strata, however thick they may become. Hence the bones bend, or, what is just as common, they break on one side only, like a roll of paper, while the other side is simply stretched across the seat of fracture, and the central marrow is crushed (willow fracture, *infractio*). The most characteristic deformity is that of the thighs and legs, which invariably bend outwards under the weight of the body, while the tibia at the same time slides inwards upon its lower epiphysis (*genu varum*).

§ 637. The effect of rickets on the growth of the occipital bone is worthy of especial notice. This bone is more exposed to mechanical pressure than any of the other flat bones of the skull. The weight of the brain upon its inner surface exerts a direct counter-pressure upon any support on which the patient's head may rest—such as a pillow. Should the periosteum undergo any exuberant proliferation, the young and yielding tissue, before it can become ossified, must necessarily waste under the influence of this double pressure; accordingly the occiput is not thickened by the apposition of new layers from the periosteum, while on the other hand the absorption of the *tabula vitrea*, which keeps pace with the growth of the brain, proceeds at its usual rate. The result is that the flat part of the occipital bone comes to exhibit thin spots here and there, and finally even actual holes, only filled in by the dura mater and the periosteum. (Soft occiput, *Craniotabes*.)

§ 638. The degree of alteration which the skeleton may undergo in any single case depends partly on the intensity, partly on the duration of the disease. Should it be arrested, the supernumerary layers undergo a subsequent ossification and are replaced by an extremely dense, hard and heavy bone-tissue. The various curvatures and nodular swellings of the bones are thereby rendered permanent; all the more so, as the bones, after the subsidence of the rachitic process, usually stop growing. It seems as though the store of material, and the capacity for regular ossification, had both been exhausted by the violence of the disease. The patient remains stunted, at any rate below the average stature, and the lasting deformities of the limbs, the thorax and the pelvis, are a perennial source of suffering and inconvenience.

2. Inflammation.

a. General Remarks.

§ 639. A general view of all the morbid changes included under the term "inflammation of the bones" makes us wonder equally at their great clinical diversity, and their singular anatomical uniformity. Most inflammations of bone run a course of one-sided acute growth; the most striking deformities of outline, the most profound qualitative changes, are operated by the very same means as those employed in the physiological enlargement of the bone, *sc.* by the development of bone from periosteum and from cartilage, by the formation and extension of medullary spaces in its interior. I have already pointed this out in § 627. We can now appreciate the bearing of those observations. The sole deviation from the physiological type, one, however, which leads to the most serious consequences, is the formation of pus. The occurrence of suppuration introduces infinite complications into the whole course of the inflammatory process; repair can only be brought about by circuitous methods, which, owing to the local peculiarities of the osseous texture, are less certain in their operation than those which enable a wound of the soft parts to heal by the second intention.

§ 640. Taking the histology of the NON-SUPPURATIVE forms of inflammation first, we begin with OSSIFYING PERIOSTITIS (*P. ossificans*). The periosteal inflammation manifests itself as an augmentation of the physiological activity of the tissue. According to the normal law of periosteal growth, successive layers of new bone are deposited; we get inflammatory hyperostoses, periostoses and exostoses (*see* § 673). Here and there we find a stage of development which is normally transient, persisting for an undue length of time; thus in the repair of fractures we often have the large accumulations of "osteoid cartilage" known as *callus;* again, the due conversion of the spongy osteophyte into compact tissue is occasionally much delayed (*spina ventosa*); upon the whole, however, matters take their usual course so far as the bone itself is concerned. Not so in the parts which surround the bone. *Virchow's* careful investigations have proved that in connexion with well-marked ossifying periostitis, bone may also be developed outside the periosteum (*Parostosis*). The tendency towards, and the capacity for "bone-formation" spreads, as if by contagion, to the connective tissue which is continuous with the periosteum, to the intermuscular connective tissue, to the sheaths of the nerves and vessels.

It may be objected that these are really exostoses, which, although extending to a distance from the parent bone, are yet invested by its periosteum; but though the periosteum in such cases passes uninterruptedly into the parostotic bone, nevertheless, by carefully tracing it from the healthy to the diseased parts, we may assure ourselves beyond all possibility of doubt, that the parostotic bone is really situated outside the outermost periosteal lamella. I know nothing from personal observation about the way in which the parosteal connective tissue forms bone; but it seems likely that the same phenomena with which we are already familiar in periosteal growth, are repeated in this case also.

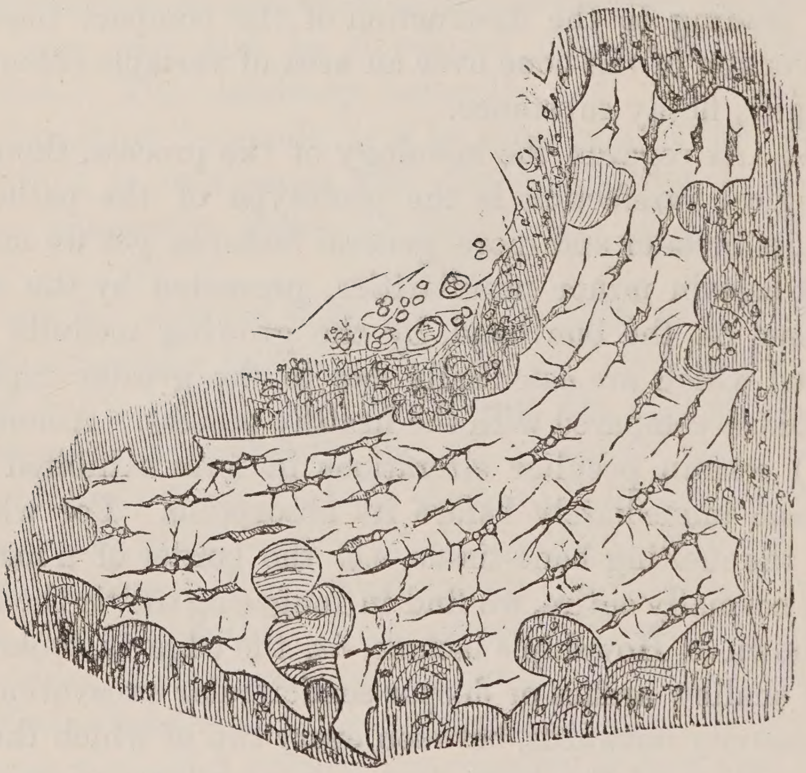
§ 641. The second factor in the non-suppurative inflammation of bone is OSSIFYING OSTITIS (*O. ossificans*), an extension of those changes to which the increase in length of the tubular bones is due, and which serve to shut off their medullary cavity from the cartilaginous epiphyses or the articular cartilages.

We know that under ordinary circumstances, only a narrow-meshed and spongy tissue is here developed. Now ossifying ostitis yields a compact tissue, frequently distinguished by the extreme tenuity of its Haversian canals, and presenting a very dense, ivory-like hardness (*eburneatio ossium*). Histologically, the process consists merely in a continuous deposition of fresh lamellæ of bone on the inner surface of the medullary spaces; it is this which gradually narrows them down to the size of the capillary vessel they contain.

§ 642. The third, a very important factor, is FUNGATING OSTITIS (*O. carnosa vel fungosa*); its action is directly antagonistic to that of the two preceding forms; it has its physiological prototype in that centrifugal enlargement of the medullary cavity which follows close upon the heels of the periosteal and epiphysal bone-growth, and thus maintains the thickness of the compact cortex and of the spongy epiphyses at a standard proportionate to the stature and age of the individual. Inflammatory irritation may cause a one-sided acceleration of this process, leading to the destruction of the compact tissue, and the conversion of the bone over an area of variable extent into a soft, fragile, fleshy substance.

§ 643. As regards the histology of the process, though the physiological rarefaction is the prototype of the pathological form in its broader and more general features, yet we must not overlook certain minor peculiarities, presented by the melting bone-tissue on the one hand, by the growing medulla on the other, and which are essentially due to the greater rapidity of the morbid as compared with the healthy process. Among these are: (1) certain peculiar alterations in form exhibited by the bone-tissue immediately before its absorption. For while the edge of the melting bone-tissue, *e.g.* the border of a medullary space, is normally entire, we find in fungating ostitis the appearances known as Howship's lacunæ, *i.e.* the edge is broken by a series of shallow arches or deeper semicircular excavations, with their concavity outwards, between every two of which the intervening portion of the bone forms an angular projection (fig. 175). A somewhat rarer phenomenon is the antecedent canaliculisation of the bone-tissue, which *Volkmann* was the first to describe, and which he called "vascularisation." Fig. 176 is borrowed from *Volkmann*. A bony trabecula is seen to be fissured by a minute canal, which is relatively wide where it begins at one side of the trabecula, but which bifurcates about its middle; the two main branches being connected by a great number of narrower collateral channels forming a rich anastomotic network between them. The canaliculi are all bordered by toothed outlines, which here and there correspond too closely to the familiar outlines of the bone-corpuscles, to leave any doubt of their origin from lacunar anastomoses. Moreover, the intervals at which the unaltered bone-corpuscles in the immediate neighbourhood are distributed, show clearly that the line of the canaliculus coincides in position with a row of former bone-corpuscles which have been destroyed. The only question is whether the canaliculi are really occupied by capillary vessels, as supposed by *Volkmann*. I doubt this, inasmuch as I have never succeeded in injecting them from the blood-vessels, or in finding the characteristic elements of a capillary tube, such as a nucleated membrane, in their interior. Judging from the way they refract light, the contents of these canals must be identical with those of the bone lacunæ; hence I can only regard them as a further development of the nutrient apparatus provided by the system of anastomosing lacunæ.

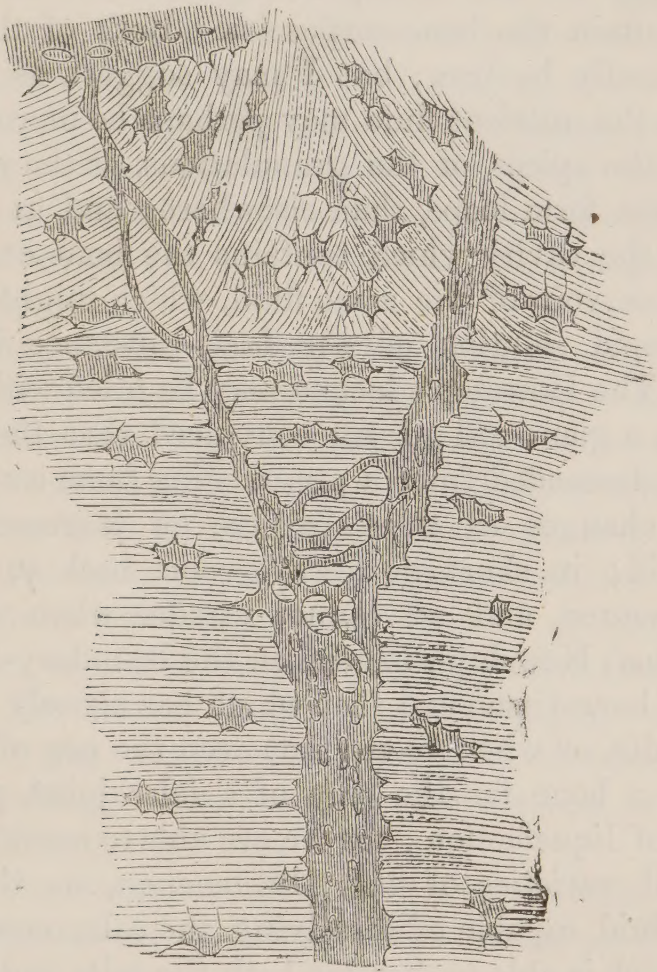
Fig. 175.



Caries fungosa. A fragment of bone showing Howship's lacunæ and bone-corpuscles infiltrated with fatty matter. $\frac{1}{300}$.

Both the Howship's lacunæ and the canaliculisation of the bone-tissue are a result of the increased afflux of fluid pabulum to the bone. We may, indeed we must, regard the ordinary nutrition of bone-tissue as carried on by the transmission of fluid matter from one bone-corpuscle to another. Should the amount of fluid passing through the bone-tissue in a given time be increased, the bone-corpuscles with their anastomotic communications must necessarily undergo enlargement; and I have reason to believe that this enlargement depends upon a direct solution of the intercellular substance in the fluid itself (*see* § 656, canaliculisation of cartilage). The solution and enlargement naturally occur earliest in the lines along which the current is most powerful; and this is probably the reason why the liquefaction does not proceed at a uniform rate along the edge of the melting bone, but gives rise to alternate excavations and angular promontories (*Howship's lacunæ*); it also explains the perforation of the septa between adjacent canaliculi along the

FIG. 176.



Fungating ostitis. Canaliculisation of the bone-tissue. After *R. Volkmann.* $\frac{1}{500}$. *See* text.

straightest and shortest lines of flow, which must naturally traverse the plane in which the osseous lamellæ are stratified, at right angles (*canaliculisation*). I hold it more prudent to confine myself to this general view of the process until further investigations have supplied us with more certain data ; hence I do not follow *Billroth* in ascribing the formation of Howship's lacunæ to the pressure of advancing granulations and capillary loops ; neither do I agree with those who regard these lacunæ as due simply to the enlargement of those cavities which normally contain the bone-corpuscles. Both of these theories may occasionally be true; but I may suggest, as regards the former, that the nutrient fluid may perhaps be more abundantly secreted at the apices of the granulations, at the points where the capillaries form loops, than elsewhere; and as regards the latter, that the cavity which contains the bone-corpuscle is a preformed reservoir of the same fluid, which might account for the more rapid solution of the basis-substance immediately around it. The Howship's lacuna may be filled with cells, or it may contain a giant-cell ; I am convinced that these elements are lineally descended from a pre-existing bone corpuscle ; but even such changes as these involve an increased afflux of nutrient fluid ; in short we always come back to this as our ultimate resource, and we cannot wonder when we find (in *mollities ossium*) Howship's lacunæ on the boundary-line between the normal bone-tissue and that which has already parted with its earthy salts, or when we see that even the peg of dead ivory, driven into a bone for the cure of a false joint, presents the same mode of liquefaction ; for we are able to assume a common cause for all varieties of the phenomenon, *sc.* the irregular action of a fluid capable of dissolving the calcareous salts only, or of one which is able to dissolve both the salts and the organic matrix of the bone.

§ 644. (2.) Another series of peculiarities which distinguish the morbid from the physiological rarefaction of bone is found in the behaviour of the medulla.

In accordance with a very generally accepted view of *Virchow's*, the condition of the inflamed medulla (putting suppuration aside) is identical with that of red or fœtal marrow. This view would bring the morbid appearances into the closest possible relation with their physiological prototype ; for we know that it is this very sort of medulla which is first produced during the physiological enlargement of the medullary cavity, and which is perhaps converted afterwards into the "oily marrow." Its minute structure also lends support to this analogy. In either case we have a granulation-tissue composed of small cells and abundantly permeated by capillaries. Notwithstanding all this, however, I think more stress ought to be laid on the inflammatory character of the whole metamorphosis. Fungating ostitis is attended throughout its entire course by a very active hyperæmia of the medulla. This is associated with a proliferation of the medullary parenchyma, causing a direct increase in its bulk, and that at the expense of the compact tissue. The cells of the oily marrow part with their oil; they divide repeatedly; and this is the point at which we are able to put our finger on the internal and thoroughly heterologous growth of the marrow.

But its outward growth, the advance of the medullary cylinder against the bone-tissue, must now be looked at from its positive rather than from its negative side. The surface of the cylinder is studded with fungous granulations which bore their way into the bone in all directions, detach and perforate the cartilage, and finally, when they have reached the surface, spread out in exuberant masses of fungoid proliferation. This independent, unbridled outgrowth of the medulla, contrasts somewhat with the modest functions of a stop-gap, to which it is restricted in the course of physiological rarefaction, and deserves accordingly to be specially characterised as an "inflammatory" phenomenon.

§ 645. Suppurative inflammation is met with partly in the same localities as the non-suppurative forms, partly on the free surfaces which enclose the joints. Suppuration of the periosteum and the medulla represents an exuberant over-production of those young cells which constitute the inner, osteoplastic layer of the periosteum, and the tissue of the medullary granulations. The result is the same in either case; a liquefaction of the affected tissue, and a more or less abundant accumulation of pus. Pus-formation on the articular surfaces must be looked at from an essentially different point of view. The articular cavity is an interstice in the connective tissue for purposes of movement (§ 265, *et seqq.*); as such, it is related to the serous sacs;

on the other hand, the structure of the synovial membrane recalls that of a mucous membrane by its thick stratum of connective tissue and double coat of epithelium. Pathological, and more especially inflammatory changes, reflect this hybrid character in some degree; for we find the synovial membranes yielding sero-fibrinous exudations like those on serous surfaces, and catarrhal purulent secretions like those on mucous membranes. The serous and sero-fibrinous transudations (*Hydrarthrus*) as well as the purely fibrinous exudations (*Arthromeningitis cruposa*) offer no features of histological interest. Suppurative inflammation of the synovial membrane (*Arthromeningitis purulenta*) according to *Volkmann's* views, which I adopt, is, at least in its earlier stages, an acute purulent catarrh, a blennorrhœa of the joint. After the normal epithelium-cells have been shed, the connective tissue furnishes masses of pus-corpuscles, without any break in the continuity of the surface; these render the pellucid contents of the joint turbid, and gradually convert them into a thickish pus, rendered viscid by the admixture of synovia. As the disease progresses, matters take a turn for the worse, owing to the irritation of the articular cartilages by the stagnant and therefore in one sense decomposing pus; this irritation causes a superficial ulceration, which may destroy the cartilage layer by layer, and then invade the bone itself. The disintegration of the cartilage in these cases is due to a process beginning with a fissiparous multiplication of its cells, and ending in a total dissolution of cells and intercellular substance alike. Vertical sections through the cartilage exhibit the earliest signs of nuclear and corpuscular fission in about the tenth or twelfth layer of cells counting from the surface. The first steps in the process are identical with those which usher in simple overgrowth of cartilage; we find groups of from four to ten elements, which still retain the distinctive character of cartilage-cells, and are enclosed in a common capsule. Nearer the surface the cartilage-cavities are much dilated, the capsules grow less and less distinct, and the cartilage-cells are replaced by ordinary pus-cells. The basis-substance has meanwhile become finely-granular and cloudy; towards the surface it wastes progressively away and finally melts into the contents of the joint. This complete liquefaction of the matrix naturally lays open those cartilage-cavities which are most superficial. The pus-corpuscles, most of which have degenerated into fatty or fatty-granular *débris*, mingle with the pus already collected in the joint; a semicircular erosion of the free border remains for some time longer; and with it, the last vestige of the cartilage disappears.

We have no ground for refusing the name of true ulceration to this form of disease. The terms "softening" or "maceration" of the cartilage, which are preferred by many writers, only express one part of the change, and take no account of the evident activity of the corpuscular elements. The ulcer presents itself to the naked eye as a sharply-defined, and usually very shallow excavation—as a superficial erosion—commonly situated where the opposed surfaces are in contact with each other, but which gradually spreads over the entire articular surface, and, as already stated, increases in depth by involving successive layers of the tissue.

§ 646. I have already said that suppuration introduces an element of peculiar danger into the course of inflammations of bone. This is chiefly due to the circumstance that the structure of the bones does not yield readily to expansile forces. Suppuration, however, like all changes attended by an over-production of corpuscular elements, demands space, and sometimes a great deal of space; and the mechanical force exerted by the repeated division and multiplication of the cells is too great to be resisted by the tension of the blood in the vessels, when the two forces are opposed to each other in a confined space which is at once inadequate and incapable of expansion. In this way, *i.e.* by squeezing and tearing the vessels, suppuration gives rise to the most manifold and profound disturbances of nutrition, which, so far as the bone-tissue is concerned, are all included under necrosis. The bone dies, now in small, now in larger portions; the sequestra, as foreign bodies, require a fresh inflammation for their removal. This, however, accomplishes the desired result but slowly, if at all; for the continuity of the compact tissue can only be dissolved very gradually. Hence the interminable course of all inflammatory diseases of the bones and joints when suppuration has once set in.

Having thus reviewed the more important of the textural changes which attend inflammation of the bones, we will now endeavour to trace its consequences in a few examples selected for their frequency and illustrative character.

b. THE INDIVIDUAL FORMS OF INFLAMMATION.

1. *Traumatic Inflammation.*

§ 647. The great solidity of the skeleton is meant to protect the organism from external violence. Many a blow and push is broken by the bones of the cranium and the extremities, which, but for their interposition, would have destroyed or damaged the most vital organs. But this very function renders the bones peculiarly liable to wounds and fractures which demand the utmost care of the surgeon, owing to the great importance of restoring their interrupted continuity. Does nature help his efforts? It would almost seem as though she did, when we see how any injury to a bone, in its capacity as an inflammatory irritant, sets a whole train of textural changes on foot, with a view to the reunion of the separated parts. A few examples will serve to place this clearly before the reader. For purposes of illustration I choose a case of fracture of the thigh-bone with longitudinal displacement, such as often comes under the surgeon's notice.

§ 648. Suppose the femur of a well-nourished adult fractured obliquely in its middle third. The line of fracture trends from below upwards and outwards. The lower fragment is displaced upwards to the extent of one inch; the upper fragment to the same extent downwards; and both are fixed in this abnormal position by the contraction of the powerful muscles which surround them on every side. The medullary cavity is laid open in each of the broken ends; numerous vessels, among others a large branch of the nutrient artery, are torn across; in consequence of this, a fresh blood-clot fills up whatever gaps there may be between the fractured surfaces and the neighbouring soft parts. Periosteum and medulla are partly crushed, partly twisted and detached. They respond to the violent stimulus by the immediate onset of an ossifying ostitis and periostitis.

§ 649. The ossifying periostitis, in a few weeks' time, furnishes a layer of osteoid tissue from 4 to 6 lines thick, which is known as *callus* or *callus-cartilage* (§ 139). The proliferation is most active at the edges of the fractured bones, extending from 2 to 3 inches in either direction, and sloping gradually into the level of the normal bone. Where the fragments overlap each other, and their respective periosteal coverings are in contact, the periosteal proliferations coalesce to form a single mass; this undoubtedly solves the main problem of repair; for the osteoid tissue need only be converted into true bone, to make the union, already intimate though weak, durable and firm. This ossification, however, requires rather a long time for its completion (from four to five months). It begins at the periphery, where the inflammatory irritation was least active, and spreads from thence to the fractured surfaces. The resulting bone-tissue is at first very lax and porous; its bone corpuscles still resemble the plump cells of the osteoid cartilage; they are large, and furnished with only a few short processes; the similarity of the fundamental tissue to cartilage is often indicated by the remains of capsular outlines, like areolæ, round the bone-corpuscles. It is only at a later period that a series of typical bony lamellæ are deposited on the inner surface of the medullary spaces; the size of the latter undergoing progressive diminution, until at length Haversian canals alone remain, and instead of the spongy callus-bone, we have a compact tissue of faultless texture and hardness.

§ 650. The effects of the ossifying ostitis are far less striking; indeed, if we regard the restoration of a nearly normal bone as the final object of the reparative process, it would almost seem as though the tendency of the ossifying ostitis were hostile to its fulfilment. The restoration of the bone to its normal state involves the restoration of a continuous medullary cylinder; but here it seems as if each of the fractured ends wanted to close up on its own account; for a deposit, first of cartilage, then of bone, fills up both orifices of the medullary cavity—a phenomenon which appears, at least in fractures unattended with displacement, to be rather inappropriate. This plug, in the earlier stages of its development, used to be known as "internal callus," a term which, from a histological point of view, is unimpeachable. Its conversion, first into true bone, then into compact tissue, occurs just as in the external variety of callus.

§ 651. The following is now the condition of the seat of fracture: we can feel, even through the soft parts, a hard mass of considerable size, which is, as a whole, spindle-shaped. On section, we come first of all upon a succulent connective tissue, already tough and fibrous in parts, which is continuous with the periosteum by its inner surface. Next to this is the callus, with its irregularly tuberculated surface, in a more or less advanced stage of ossification. The callus entirely fills the two re-entering angles formed by the lower fragment with the upper half of the shaft, and by the upper fragment with its lower half, so that the transition from the upper to the lower part of the diaphysis is operated by an S-shaped bridge of bone. On sawing through the seat of injury in the plane of this S, the line of fracture through the compact substance may still be distinctly recognised; this condition endures for a long time. Years elapse before fungating ostitis breaks through the double layer of compact bone which intervenes between the corresponding ends of the interrupted medullary cylinder. This is the final step towards a restoration of the bone to its former state. The same end is served by the peculiar rounding-off of the fractured part after the inflammatory irritation has subsided and the excess of periosteal proliferation, to which the irregularities of the fractured part were due, has undergone a secondary absorption.

§ 652. Matters naturally run a simpler course when displacement has either not occurred at all, or has been rectified in time by surgical interference; on the other hand, fresh difficulties arise when the broken ends are not only displaced, but pulled asunder. In the latter case, either union does not occur at all (fracture of patella), or what is known as a false joint results, owing to the independent healing of each of the fragments, which comes to oppose a rounded end, often coated with a persistent residue of osteoid cartilage, to its fellow. It is only when the separation is very trifling that a firm union can take place. This was long believed to depend on the capacity for organisation possessed by the blood, which is undoubtedly extravasated between the fractured surfaces during the injury. *Virchow's* investigations have shown, however, that *parostosis ossificans* (§ 640) comes to the rescue and fills up the gap by an independent formation of new bone from young connective tissue.

The process of repair after wounds of bone is precisely the same as after fracture. In either case, any profound disturbance of the healing process can only be caused by necrosis of pieces of bone of various sizes, whether owing to their having been splintered off during the original accident, or because their supply of nourishment has been stopped during the subsequent inflammation. This subject will be discussed in the ensuing section.

2. *Necrosis.*

§ 653. The complete arrest of nutrition in a certain, usually circumscribed portion of bone, is followed by a series of inflammatory changes in its neighbourhood, which finally result in the separation and expulsion of the dead from the living tissue. The course of these changes is usually determined by the cause of the necrosis in each case. In traumatic necrosis, the separation of the dead bone is occasionally complete (comminuted fractures, &c.) from the first, but the fragment is too deeply situated to allow of its being expelled at once. Suppurative periostitis is usually the proximate cause of necrosis even in traumatic cases, as it is the first and only cause of it in most others. Suppurative periostitis culminates, as already said, in an accumulation of pus between the periosteum and the bone. No preformed cavity susceptible of dilatation exists in this region; but, in young and growing bones more especially, the "cambium-layer" (*M. Schultze*) of the bone is so soft as hardly to offer any resistance to the detachment of the periosteum. Only the numerous vessels which pass from the periosteum into the cortical layer of the bone have to be torn across; and the number of vessels thus damaged depends on the intensity of the inflammation, *i.e.* upon the quantity of pus produced. It is to this rupture of the vessels that the frequency of superficial necrosis after suppurative periostitis is chiefly to be ascribed. The cause of the entire arrest of vitality in the outer third of the compact substance may very plausibly be sought in a direct interruption of its blood-supply, which is naturally derived from the periosteum. And though necrosis is not by any means an invariable consequence of suppurative periostitis, we must not on that account reject the very obvious causal relation between the two phenomena; nay, we ought to ascribe the exceptional absence of necrosis to circumstances peculiar to each case, as *e.g.* to the timely compensation for the arrested circulation through the cortical layers, afforded by the vessels of the medulla. It is only the pus itself which must be regarded from the first as something outside the pale of the organism, as, in this sense, "dead." Its presence excites a sequestrating inflammation both in the periosteum and the bone. The former is very soon converted into a pyogenic membrane which shuts off the organism from a product which it has itself secreted. A fungating ostitis is set up in the bone; its task is to shut off the organism on this side also by a rampart of granulation-tissue. This ostitis is fed from the medulla; it extends into the compact substance as far as its vessels remain pervious to the blood. Cases occur, in which it is developed on the outer surface of the bone, where the Haversian canals become dilated, and a number of highly-vascular granulations sprout up and ultimately combine to form a continuous layer, which unites with the detached periosteum to form a complete lining membrane for the abscess-cavity. More commonly, indeed, the outermost layers of the compact substance have been too long cut off from circulation and nutrition to allow of their vitality being restored from the medulla; in such cases the fungating ostitis does the work of a sequestrating inflammation, detaching the lamellæ of dead bone and mingling them with the pus which fills the abscess-cavity. The dead bone is then termed the "sequestrum," the fungating ostitis which separates it, "demarcation." This demarcation may require months and years for its completion. During the whole of this period the suppuration never ceases; the detached periosteum, however, mindful of its old function, developes a layer of new bone immediately under the pyogenic surface; this layer may in time attain a very considerable thickness. The capsule of bone thus produced is called the "shell" (Todtenlade); it lodges the more or less isolated sequestra in its interior. The neighbouring periosteum which still adheres to the bone takes part in the process by an ossifying periostitis. Osteophytes and exostoses of various shapes are thus produced to a distance of several inches above and below the affected part. All these inflammatory phenomena, far as they may extend, disappear as soon as the sequestrum is removed. Even the shell of new bone shrinks; and as the abscess-cavity undergoes obliteration, the shell becomes applied to the surface of the bone; the exostoses disappear and the bone resumes its normal form.

3. *Simple Caries.* (*C. simplex.*)

§ 654. I have already (§ 645) described the behaviour of the cartilages during suppurative inflammation of the joints. I traced the course of the disease as far as the formation of a true ulcer in the cartilage, which, extending in depth by the progressive implication of successive layers of the tissue, threatened to destroy the articular covering throughout its entire thickness. I broke off at this point so as not to encroach on another process, which is usually evolved from the primary forms of articular suppuration, but which I had only time to point out in those general introductory observations. I allude to simple caries of the bones.

Caries had at one time a vague and extensive denotation. Wherever morbid changes had given rise to an eroded and worm-eaten condition of a bone, caries was at once said to exist; so that we could speak of syphilitic and cancerous caries, we could designate the destructive effects of aneurismal tumours upon the bones by the word caries, &c. The tendency of the present day is to limit the term to two forms of true ulceration of bone, one of which is called "simple caries," the other "fungating caries." Simple caries corresponds to what, in the skin, we call an "indolent ulcer." The surface of a bone exhibits a loss of substance which gradually increases in depth, but remains shallow upon the whole, and from whose floor small quantities of pus, together with shreds of decaying tissue, are continually being thrown off. The pus, and generally, all the fluid constituents of the secretion, are derived from the denuded medullary tissue. This, at a certain depth, is in a state of hyperæmic proliferation which passes, near the surface, into an exceedingly dense corpuscular infiltration. The cells occupy all the pores of the bone-tissue; they leave no room for blood or blood-vessels; the latter are compressed, and finally converted, together with the cells, into molecular *débris.* These not unfrequently form a continuous layer upon the surface, being held together only by the still intact trabeculæ of the spongy substance of the bone. This intervention of the bone-tissue in the inflammatory process exerts a positively detrimental influence upon its course. It renders the free development of a granulating surface impossible by refusing the necessary space, and allows the cells to choke one another by their own luxuriance; again, by its firm connexion with the healthy trabeculæ of the deeper layers, it retains the fetid products of decomposition, which should have been cast off long before, in contact with the ulcerated surface, like a slough, and so gives the whole process an indolent and sanious character.

§ 655. As has been already remarked, the articular ends of the bones are the favourite seat of "simple caries." It sets in as soon as the cartilage which coats the articular surfaces is finally destroyed, and the bare bone is left projecting into the cavity of the joint, which is filled with pus and communicates with the air by fistulous passages. The way in which the destructive changes are modified by the mutual pressure and friction of the opposed surfaces, is highly characteristic. Not by an inflammatory sequestration as in fungating caries, but by sheer mechanical violence, minute portions of bone-tissue are successively detached together with the *débris* which surround them. They may be felt like grains of sand in the thin, sanious pus which is secreted by the interior of the joint. The destructive process which *Volkmann* very aptly calls "molecular necrosis," though slow in its progress, nevertheless causes in time very extensive losses of substance in the condyles, the acetabulum, &c., followed by marked shortening and distortion of the limbs. The ulcer is invariably superficial. It is sharply circumscribed, and relatively smooth; the infiltration extends at most to a depth of from one-half to one line into the substance of the bone. According to *R. Volkmann*, who, in his admirable treatise on diseases of the bones, enters very minutely into their pathological histology, the zone of actual inflammation and suppuration is not unfrequently followed by a layer of abnormally dense bone-tissue a line thick. It looks as though the bone were trying to protect itself by an ossifying ostitis against the further spread of the disease. In reality, this sclerosis is due to a minor degree of inflammation in the tissues adjoining the actual seat of morbid action.

The non-articular forms of simple caries originate in circumscribed periosteal suppurations; these are mostly syphilitic, and are often complicated with gummata. (*See* below.)

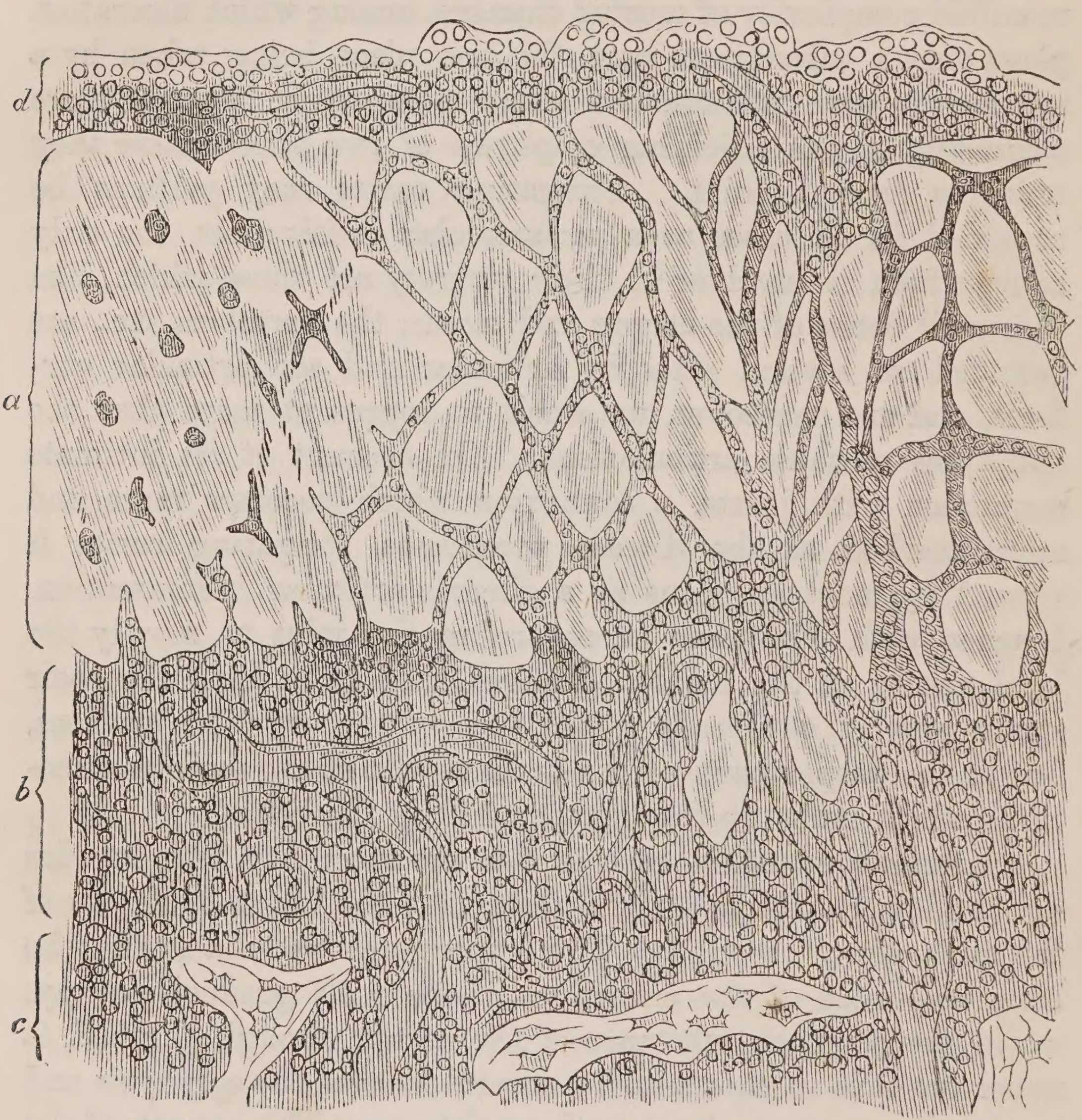
4. *Fungating Caries.* (*C. fungosa.*)

§ 656. While simple caries is essentially an ulcer of bone and nothing more, fungating caries presents us with a far more manifold complexity of morbid changes, among which ulceration plays only a subordinate part, the first place being taken by a non-suppurative inflammation either of an entire bone, or more commonly of the adjoining epiphyses of two bones where they unite to form a joint. Fungating caries may perhaps be regarded in all cases as a periarticular ostitis; for the only bones which it involves in their entirety are those which, like the small bones of the carpus and tarsus, the vertebræ, &c., are bounded on several sides by articular and semiarticular surfaces, and are, moreover, too small to represent more than the epiphyses of these articulations. On account of its intimate connexion with joints, a connexion which becomes more and more marked as the disease progresses, fungating caries is viewed by most surgeons as a chronic articular inflammation. I agree with *Volkmann* in regarding the joint as merely the local centre of the morbid changes, and in seeking for their starting-point, as already stated, not on the articular surfaces, but in the deeper parts of the parenchyma of the various structures which make up the joint, especially the bones.

A fungating ostitis, such as that described in § 642, invades *e.g.* the lower epiphysis of the femur and the upper epiphysis of the tibia simultaneously. The hyperæmic medulla swells, the bony trabeculæ of the cancellous tissue melt gradually away, while the compact substance of the cortex, though thinned, is never too thin to maintain the natural form of the epiphysis and to give it some sort of external consistency. The growth of the medulla takes the direction of the articular surface from the first. The medullary spaces and Haversian canals which immediately underlie the cartilage open out—if we may use this term;—the exuberant granulations of the medulla protrude from them, and soon form a continuous layer, intercalated between the cartilage and the bone (fig. 177, *b*). The cartilage, accordingly, is somewhat raised from the surface of the bone. The extent of this separation, *i.e.* the thickness of the pad of granulations, may amount to nearly one line.

It is obvious that so considerable an inflammatory movement in the parts immediately beneath the cartilage, and from which it derives its pabulum, cannot take place without affecting the nutrition of the cartilage itself. The latter is better nourished—if better nutrition consist in its being permeated by a larger amount of the fluid constituents of the blood. This overfeeding, however, is most detrimental to the specific nature of the tissue, which gradually ceases to exist as cartilage; though its corpus-

Fig. 177.



Arthritis fungosa. Vertical section, extending from the articular surface to the bone. *a.* The residue of the articular cartilage; *b.* Layer of granulations between the bone and the cartilage; *c.* Rarefied texture of the bone; *d.* Superficial granulations which set out from the edge of the synovial membrane. $\frac{1}{300}$.

cular elements may continue to be represented by a numerous but degenerate progeny. To the naked eye, a vertical section gives the idea that the cartilage is being penetrated by the granulations springing from the bone. The microscope corrects this impression; it shows that the cartilage takes an active share in the task of its own destruction. Fig. 177 is meant to elucidate the process. The zone marked *a* contains the last remnants of an articular cartilage which is fast disappearing. To the left, a few normal cartilage-cells are still to be seen, distributed at the proper intervals through a hyaline matrix. More to the right, we see the matrix undergoing rarefaction along those lines which run most directly from one cartilage-cavity to another. These obviously coincide with the path taken by the nutrient fluid in the intermediate form of physiological nutrition. The increased work thus thrown upon them leads to a sort of gradual softening, a rarefaction, which ultimately results in the development of a complete canalicular network throughout the cartilage. Shortly before the canals are finally opened, the cartilage-cavities become enlarged along the said lines; and it can easily be shown that at this stage, before any immigration of amœboid cells from the granulation-tissue can possibly have occurred, the cartilage-cells are in a state of fissiparous multiplication. The resulting elements are much smaller than the parent-cells; the contents of the cartilage-cavities, even before they come into direct contact with the granulation-tissue, are quite like the latter in structure. So that when the remains of the intervening matrix ultimately disappear, the proliferated cells of the cartilage are simply added on to the existing texture of the granulation-tissue. The canaliculi continue to enlarge at the expense of the matrix. Capillary loops burrow into them and strive to unite with the vessels which penetrate into the tissue from above.

§ 657. While the cartilage is being permeated in this way from below, a precisely similar disorder has been extending in the opposite direction, from above. It was not without intention that I laid stress on the implication of other periarticular elements besides the bones in the inflammatory process. Among them we have, first the synovial membrane, then the subsynovial connective tissue, the ligaments, and finally all the connective tissue which is in direct continuity with that already mentioned, as far as the skin. A diffuse congestion and hyperplastic state of the synovial membrane, which need not by any means be associated from the first with suppuration (*Caries sicca*), becomes concentrated in the delicate, usually somewhat overlapping fringe with which the synovial membrane girdles the cartilage. Starting from this fringe, a membrane of young connective tissue overspreads the cartilage from its edges. Like a thin, highly vascular veil, it lies at first upon the surface of the cartilage, whose white colour still shines through it. Gradually however, the most superficial layers of the cartilage take part in the inflammatory change; the cells multiply; the capsules open; and the young connective tissue, with its vessels, forces its way in on every side. The texture of the cartilage is accordingly broken up from this as well as from the opposite side. Finally the ascending growth meets that which is advancing downwards; the two coalesce and the cartilage is perforated.

When once this has occurred at a sufficient number of points, the granulations sprouting from the bone obtain the upper hand; fungoid vegetations of no great thickness spread horizontally without check; they entirely invest the cartilage and conceal it, so that the articular surface comes to be entirely made up of a mass of granulations, even though some considerable remnants of cartilage may still exist beneath it.

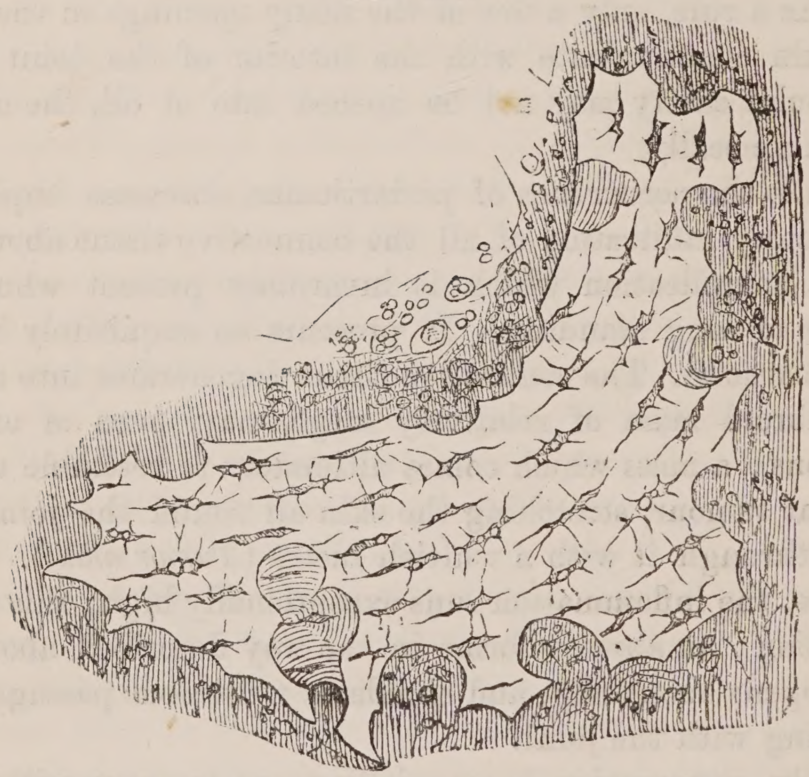
§ 658. The matter may end here. There are cases of fungating arthritis—and these cases, thanks to the timely diagnosis and rational treatment of modern surgery, are more numerous from year to year—in which the stage of suppuration is never reached, in which the granulations recede and the mobility of the joint is preserved. Indeed, granulations springing from bone, even when they form part of an articular surface, do not necessarily secrete much pus. Even in their texture they are rather analogous to the permanent formations of connective tissue, and especially to the so-called adenoid tissue of the lymphatic follicles and the alimentary mucous membrane; and this may account for their limited tendency to secrete pus from their surface (§ 105).

This shows clearly enough how everything depends on the time, manner and locality of the suppurative complication. It must be admitted broadly, that all the affected parts are extraordinarily predisposed to suppuration. First, pus may form and accumulate in considerable quantity in the cavity of the joint, at any stage of the disorder. Indeed the disease may begin as a purulent arthritis, its true nature unfolding itself at a later period in a fungoid degeneration of the deeper parts of the joint. In this case the synovial surface becomes coated with spongy granulations which unite to form a continuous layer. Should the pus make its way out, the resulting sinuses (fistulous passages) are soon lined with fungoid granulations also; the same thing happens when abscesses form in the neighbourhood of the joint, burst, and persist as blind fistulæ for an indefinite time. As a rule, only a few of the many openings in the overlying skin communicate with the interior of the joint; nay, the articular cavity may not be opened into at all, the sinuses all ending cœcally.

In fine, the occurrence of periarticular abscesses implies an inflammatory infiltration of all the connective tissue about the joint; a complication which is invariably present when the disease is of long standing. It presents an exquisitely hyperplastic character. The connective tissue degenerates into a firm, white, fibroid mass of relatively large, nay, even of colossal dimensions; a mass which comes ultimately to resemble an independent tumour, stretching the skin all round the joint, and shining through it with a whitish lustre (*Tumor albus*). Here and there, the inflammation runs exceptionally high; this causes suppuration; an abscess forms in the way described above; it usually opens externally, and simulates a fistulous passage communicating with the joint.

Finally, suppuration is especially prone to occur within the substance of the inflamed bone itself. This, caries proper, usually starts from the articular surface by a suppurative disintegration of the granulations, and spreads rapidly in depth through the entire thickness of the epiphysis. On section, we find yellow streaks and dots irregularly scattered through the congested medulla. The more luxuriant the antecedent proliferation, the more rapid and complete the subsequent disorganisation. The trabecular structure of the bone is so much thinned that a probe can be pushed through it from side to side without meeting any notable resistance. The secretion which oozes from the fistulæ communicating with the joint assumes more of a sanious character, and contains numerous fragments of bone-tissue, in which traces of antecedent rarefaction are distinctly manifest (fig. 178). The corpuscles of carious bone have repeatedly been found distended with oily matter. *Ranvier* (Archives de Physiologie normale et pathologique, Janvier, 1868, p. 69) distinguishes two stages in the death of the bone-tissue. During the first, the corpuscles present the phenomena of fatty degeneration; in the second, the actual death of the individual trabeculæ ensues. Why should we not admit this view, even though we cannot agree with its respected author in regarding the death of the bone-tissue as the pivot of the whole disorder, and the inflammation as an accessory phenomenon?

FIG. 178.



Caries fungosa. Detached fragment from the cancellous tissue of an epiphysis which is undergoing suppuration; exhibits Howship's lacunæ and fattily degenerated bone-corpuscles. $\frac{1}{300}$.

It would lead me too far, were I to describe the extensive lesions to which fungating caries may give rise in the skeleton. Not unfrequently, all the small bones of the carpus or tarsus, including the adjacent bones of the arm or leg, are diseased; the "white swelling" attains the size of a man's head; and the surgeon has to resort to amputation as a last chance of saving the patient's life.

§ 659. As regards the cure of the inflammation, we may cherish hopes of it (apart from that early arrest which is alluded to in § 658) in cases where the articular surfaces are early involved in the process; for the cavity of the joint is then speedily filled up with granulations, and the surgeon may be able to moderate the general violence of the inflammation by derivation to the skin. In this way the articular cavity may sometimes be quite obliterated; the masses of granulations uniting from every side, and becoming converted into fibrous cords. The mobility of the joint is at an end; but even this drawback may be subsequently counteracted by the recently adopted practice of forcible extension.

§ 660. SCROFULOUS CARIES of the vertebral column is, in my opinion, a mere variety of fungating caries. Here, too, we have a fungating ostitis. It affects the cancellous tissue of the vertebral centra; if we examine these in section, we find roundish cavities, more or less confluent, amid the network of bony trabeculæ, filled with a perfectly soft, pale red, jelly-like substance. This substance also extends into the adjoining medullary spaces which are obviously undergoing dilatation, and may be summarily recognised as hyperplastic medullary tissue. Most striking is the deficient evolution of a truly inflammatory hyperæmia. Can it be that this does not occur at all? I prefer to believe that the early occurrence of an œdema or mucous softening of the young connective tissue compresses the blood-vessels and so gives rise to anæmia and further nutritive disturbances. These consist of a cheesy metamorphosis beginning in the interior of the mass of granulations and gradually extending from this point in all directions. The "crude tubercles" (§ 33) which appear in the interior of the bodies of the vertebræ, must naturally have impressed the unaided eyes of the older observers more forcibly than the insignificant pale-grey infiltration which surrounds them; hence it is that down to the present day, the process has been called "tuberculous." Of course it cannot be denied that it may lead to tuberculosis—I mean to constitutional miliary tuberculosis—but it does this only in its quality of "caseous" inflammation, rather seldom, and only in the case of children.

The further course of the disease justifies us in calling it a "caries." The cheesy deposits, chiefly situated in the anterior half of the bodies of the vertebræ, soften and melt into a pus-like fluid; this seeks and finds an issue by stripping off the periosteum and the longitudinal ligaments of the vertebral column, in front of which it accumulates and then gravitates downwards. Of course, all the pus which is ultimately voided at some remote point, *e.g.* at Poupart's ligament, is not a product of the vertebral caries; most of it results from inflammation of the membranes, periosteum, tendons and fasciæ along which the abscess has burrowed its way downwards.

§ 661. A striking fact, and one which militates especially against the belief that fungating caries is primarily an inflammation of the joints, is that the intervertebral disks, which are justly held to be imperfect joints, either escape the inflammatory changes entirely, or become involved at a relatively late stage in the disease. They are usually destroyed by suppuration from without, seldom by a penetration of the fungoid granulations from the medulla into their substance. Not so with the articulations between the transverse processes and the capitula of the ribs, which, once within the inflamed region, take part in the process by an ordinary fungating caries. The suppurative disorganisation of the joints, perfect or imperfect, is of the highest clinical interest, inasmuch as it relaxes the union between the vertebræ, and facilitates those dangerous displacements, of which I need only mention Pott's curvature, and the almost invariably fatal luxation of the atlas—of the *dens epistrophei*—against the spinal cord.

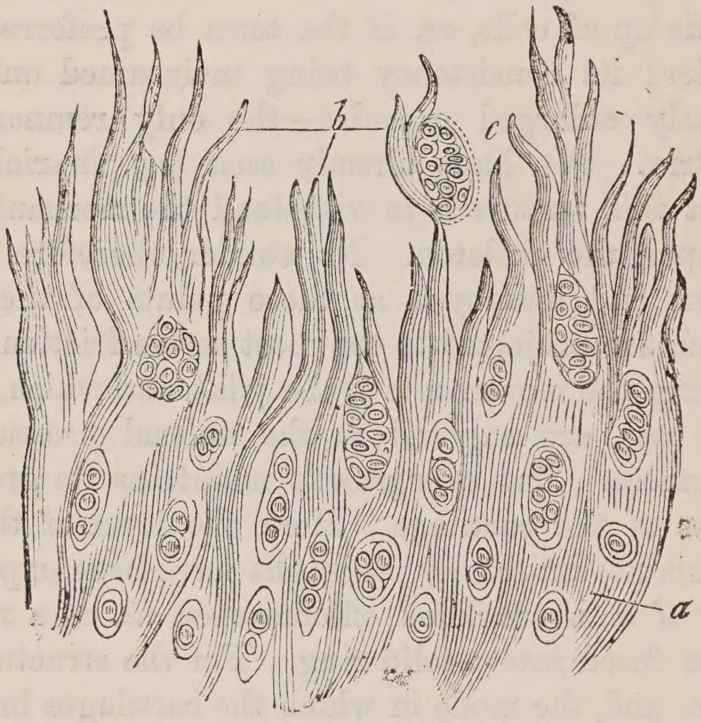
APPENDIX I.

ARTHRITIS DEFORMANS.

§ 662. This disease is also known under the name of *malum senile articulorum*, because it usually affects persons advanced in life, or actually old. The process is essentially one of those lingering inflammations which accompany the decay of the organism, like the atheromatous disease of the internal coat of the arteries with which we are already familiar. The inflammatory irritation of the articular surfaces is not powerful enough to cause suppuration; it only sets up a hyperplastic overgrowth, in which all the constituents of the joints, the cartilages, and the synovial membrane, take an equal part. The synovial membrane produces a number of pedunculated, fatty polypi of considerable size, and a quantity of finer dendritic vegetations, villi and fringes, which give the surface a peculiar roughness, aptly compared by *Volkmann* to that of a sheepskin. The cartilage undergoes a perfectly homologous proliferation, like that in rickets (*see* § 79). This begins in the outermost, the most superficial layers of the tissue, and gradually extends in depth. The cells divide; the usual groups of from eight to twenty largish elements are produced, between which, should nothing interrupt the course of their development, the remains of the matrix grow more and more narrow, the final result being a tissue made up of cells, or, if the term be preferred, of very large vesicles; its consistency being maintained only by the simultaneously enlarged capsules—the only remnant of the former matrix. We have already seen (*e.g.* in rickets) how utterly unfit this texture is to withstand the mechanical forces which act upon the skeleton. No wonder, therefore, that it is broken down and destroyed at those points of the articular surface which are subjected to the most active friction upon one another during the movements of the joint, and which, when the joint is at rest, are exposed to the mutual pressure of the opposed surfaces. The overgrowth maintains its ground only at the edges of the cartilage. Here, the level of the surface rises, and this not uniformly, as might have been expected, but in the form of a tuberculated efflorescence, *i.e.* of a number of ecchondroses fused into a solid ring. For the structure of this efflorescence, and the mode in which the cartilages break down at their point of contact (fig. 179), I must refer the reader to the descriptions already given in §§ 79 and 41. We will now devote our attention to the unavoidable results of this peculiar combination of formative and destructive changes.

§ 663. The annexed woodcut (fig. 180) represents an imaginary section through an affected joint; it shows the coarser features both of the peripheric overgrowth (*c*) and the central softening of the cartilage. The dotted lines (*b b*) indicate the normal outlines of the latter. The articular surface *a* is still coated with a thin layer of cartilage, fibrillated on its surface, while the opposite cartilage has been worn down to the bone, the latter being laid bare in two places. The disease is not usually complicated by caries of the denuded bone. On the contrary, the bone shows a tendency to protect its medullary spaces, towards the articular cavity, by an ossifying ostitis; so that to the naked eye, it appears to be coated with a smooth, white plate of exceedingly dense bone. This plate usually presents evident marks of the mechanical violence to which it has been exposed. The irregularities of the one surface channel corresponding grooves on the other (Schliffflächen). And the matter does not rest here. A new factor, of the utmost importance for the further course of the disease, steps in. The brittle bone-tissue is as incapable of resisting the continued rubbing and eburnation to which it is subjected, as two pieces of pumice-stone when rubbed together. The bone is gradually worn down, and the most extreme distortion of the joint becomes possible. Entire epiphyses gradually disappear; the neck of the femur is absorbed, and though we still find a head projecting from that bone below the trochanter, this is not the old head, but really a cast of the acetabulum, whose centre consists of a remnant of

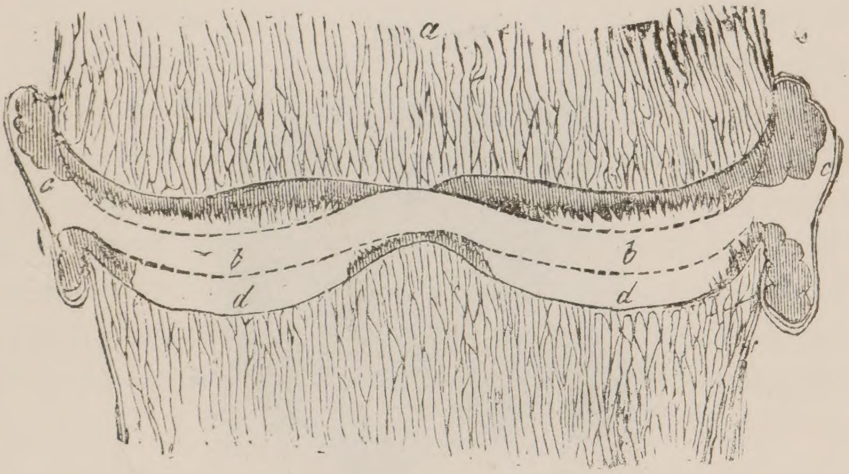
FIG. 179.



Arthritis deformans. Vertical section through an articular cartilage which is breaking up on the surface. $\frac{1}{300}$.

the neck, while its circumference is formed by the peripheric efflorescence already alluded to, which has become calcified in the meantime. It is an interesting circumstance that the latter should continue to retain its original activity during the whole course of the disease, which may last for years. As shown in fig. 180, it actually bulges over the edge of the articular surface, because it cannot find room to grow between the opposed ends of the mutually destructive bones. It overlaps the edge and spreads downwards along the outer surface of the bone, pushing the capsule of the joint before it, and jamming it between itself and the periosteum. Its plasticity readily enables it, in such cases as that just referred to, to fill up the annular depression which is left between the truncated neck of the femur and the spheroidal surface of the acetabulum. A vertical section at once reveals the true nature of the spurious articular head.

FIG. 180.



Section of knee-joint (semi-diagrammatic) in *malum senile.* *a.* Lower epiphysis of femur; *b.* The former outlines of the cartilage; *c.* Marginal proliferations; *d.* Polished surfaces.

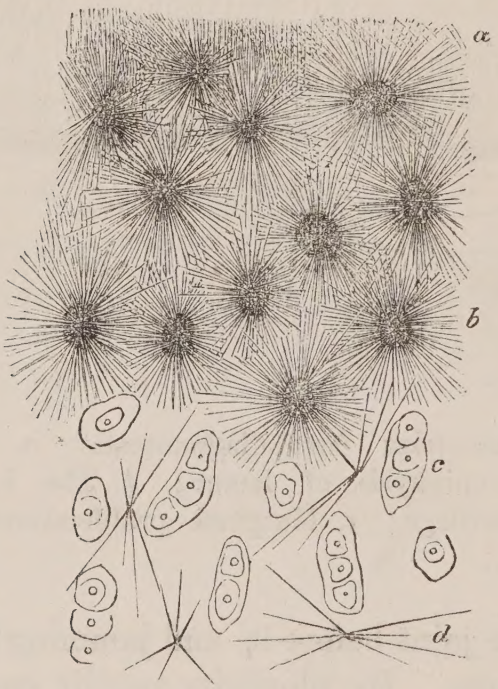
The hip-joint is the favourite seat of *arthritis deformans.* Next in order of frequency come the sterno-clavicular joint, the knee, and the interphalangeal joints of the hands and feet.

APPENDIX II.

ARTHRITIS URATICA.

§ 664. The presence of an excess of uric acid in the blood is the chemical expression of a constitutional disease of whose essential nature we are still ignorant, viz. gout; it leads to the abnormal precipitation of urates in various parts of the body; among others in the interior of the joints, and in the parenchyma of the cartilages, bones, and membranes which enclose the joints. From a histological point of view, this infiltration of the solids of the body with uric acid is quite analogous to their infiltration with earthy salts, amyloid matter, oil, or pigment; but as it only occurs in gout, I refrained from discussing it in the General Part of this work.

FIG. 181.



Arthritis uratica. Vertical section through an articular cartilage infiltrated superficially with urate of lime. *a.* The surface; *b.* Cartilage-cavities with tufts of crystals; *c.* Cartilage-cells not yet infiltrated, undergoing division; *d.* Isolated needle-shaped crystals in the basis-substance. After *Cornil* and *Ranvier.*

The form which the uric-acid infiltration takes in cartilage is most worthy of notice. The cartilage-cells are the chief depositaries of the urates of soda and lime. They form the centres of the stellate bundles of crystals by which the tissue is permeated. I don't wish to say that the cells take any active part in the morbid process; the salts are first deposited where there is most room for them, *sc.* in the cartilage-cavities; in any case, however, the appearance of the infiltration under the microscope is highly characteristic (fig. 181). In the ligaments about the affected joint, and in the medulla of the bones, the crystalline tufts are distributed without any reference to the texture of the parts. They form actual nodules as big as a pea and bigger, whose aspect leads us involuntarily to inquire how space can have been found for so bulky a deposit.

The uric-acid infiltration naturally irritates the affected parts both chemically and mechanically. It commonly gives rise to chronic congestion of the synovial membrane and the periarticular connective tissue, with intercurrent paroxysms of acute inflammatory œdema—and finally to true suppurations, which may either be superficial, or more profound and leading to caries.

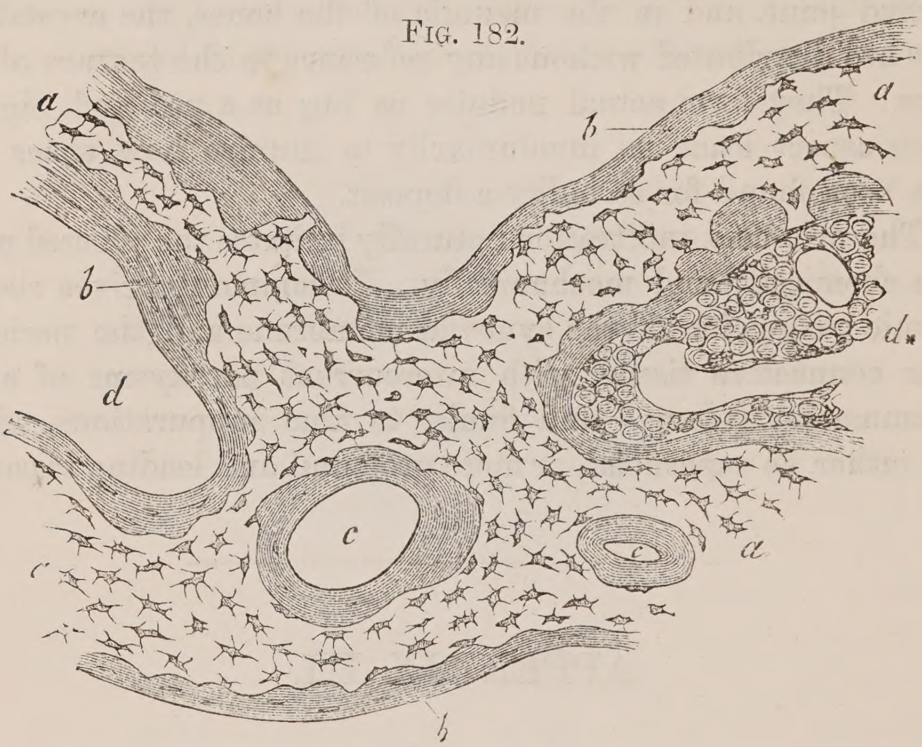
APPENDIX III.

MOLLITIES OSSIUM.

§ 665. The term osteomalacia (*mollities ossium*) has very aptly been conferred on a disease, whose chief and almost only anatomical characteristic is a decalcification and gradual liquefaction of the bone-tissue—of that to which the bone owes its solidity, Mollities ossium has been viewed as a disturbance in the chemistry of nutrition; as an inflammation; with more show of justice, as a result of venous hyperæmia, or as a premature old age of the skeleton; in a word, its etiology is still unknown. Hence we will do well to begin with an impartial description of its anatomy, before assigning it any place in our nosological system.

§ 666. As I have just observed, mollities ossium consists essentially of a softening of the bone-tissue. If we break off a minute trabecula from the cancellous texture of a bone affected with this disease, and after soaking it in carmine, examine it under a magnifying power of 300 diameters, we find a highly characteristic set of appearances (fig. 182). The trabecula is seen to consist of two different substances; it exhibits two very distinct zones, an outer one, lying next to the medullary spaces (*d*), and the Haversian canals (*c*), and an inner one which forms the axis of the trabecula. The inner zone consists of perfectly

Fig. 182.



Mollities ossium. Splinter of bone from the spongy substance of an affected rib. *a.* Normal bone-tissue; *b.* Decalcified bone-tissue; *c.* Haversian canal; *d.* Medullary spaces; *d**. A medullary space filled with red marrow. The capillary vessels are gaping widely. $\frac{1}{300}$.

normal bone-tissue; the corpuscles, with their countless anastomosing prolongations, the highly refracting, colourless basis-substance, are unaltered. The outer layer, on the other hand (*b*), exhibits a finely-striated basis-substance, deeply stained with carmine, in which only a few scattered streaks of shadow indicate the former position of the bone-corpuscles. Of their processes not a vestige remains; it seems, rather, as if a swelling of the intercellular substance were engaged in obliterating all the lacunæ together with their canaliculi. The alterations remind us too forcibly of those which the bone-tissue presents when soaked in hydrochloric acid, to leave us in doubt for one moment, that a process of decalcification (halisteresis, *Frey*) is taking place in the present instance. It attacks each of the trabeculæ from without inwards; we can trace every step of its advance by the sharp line of demarcation between the normal tissue and that which has already parted with its earthy salts. It is interesting to note that this line does not run parallel with the external contour of the trabecula, but exhibits the same sort of semicircular excavations as those which we found where bone-tissue was being absorbed in inflammation, caries, &c. (Howship's lacunæ). Hence we conclude that the removal of the earthy matter proceeds more rapidly in some directions than in others, and that Howship's lacunæ originate in this unequal progress of the decalcification. Now if, with all these facts and inferences before us, we endeavour to frame some general theory of the process, I believe that many of my readers will agree with me in thinking that the bone-tissue is deprived of its earthy salts by some acid contained in the medullary spaces and Haversian canals. The close resemblance of the outer zone of the trabecula to bone-tissue which has been artificially freed from its salts by acids, argues in favour of this hypothesis; moreover we can easily conceive how an acid, starting from the medullary canals, should penetrate with varying rapidity into a tissue which is not uniformly permeable, but is traversed by canaliculi; the rapidity being proportional to the width and number of these channels.

§ 667. Decalcification is the first stage of mollities ossium. The second follows some time afterwards; it consists in the solution of the decalcified bone-tissue. This also spreads from the medullary spaces towards the axis of the trabeculæ. The latter endure for a while as bone-cartilage; they then grow steadily thinner towards their middle, until at length they melt away and disappear. The resulting product, a mucoid substance of which nothing more is known, mingles with the contents of the medullary spaces; a part of it may continue to exist as the intercellular substance of the proliferated medullary tissue.

§ 668. How well the process just described is adapted, by gradually enlarging the Haversian canals, to convert the compact substance into spongy bone, and this again into a cavity without any osseous trabeculæ, is obvious enough. To get a just idea of the coarser appearances in mollities ossium, we must bear in mind that the liquefaction of the bone invariably proceeds from within outwards. Accordingly it is the medullary cavity which first undergoes enlargement; in the long bones, it extends from the diaphysis into both epiphyses, while in those bones which are naturally devoid of a medullary cavity, such cavities are developed; the compact tissue of the cortex becoming as thin as cardboard, but never thinner. I have never seen this residual lamina disappear; its permanence might, indeed, have been anticipated from the fact that the outermost layer of the bone derives its nourishment, not from the medullary cavity, but from the periosteum, and must therefore be less affected by a nutritive disturbance which so obviously sets out from the former.

I say expressly, "from the medullary cavity;" for I should be going a step beyond what is warranted by the facts, were I to say "from the medulla." Often indeed has the medulla been proclaimed as the seat of all the mischief; its morbid changes, however, are susceptible of such manifold interpretations, that it is really impossible to found any coherent theory of the pathology of mollities ossium upon them. The medulla is always found loaded with blood in recent cases of the disease. Wherever fat has accumulated in any quantity, it gradually disappears; so that medullary cavity, medullary spaces, and Haversian canals come at last to contain a reddish-brown, semifluid pulp, very like that of the spleen. *Virchow*, in former days at least, was fond of insisting on the identity of this red pulp with the marrow of fœtal bone. Personal investigation compels me to oppose this view. I have found a highly-corpusculated medullary tissue, like that of the fœtus, only in one very interesting case of softening of the bodies of all the vertebræ in a child five years of age. The medulla in this case presented an appearance which at once reminded me of the splenic pulp (fig. 182, *d*). Its cells were closely crowded and embedded in a stroma woven out of exceedingly delicate trabeculæ of connective tissue; between them lay scattered red blood-corpuscles and various particles of yellow and brown pigment. The blood-vessels were marked off from the parenchyma by a simple outline; they can hardly be said to have possessed a proper wall; their gaping lumina, like gimlet-holes, reminded one of the canals in the splenic pulp.

Vainly did I seek for closer analogies. In all other cases of mollities ossium which have come under my notice, the medulla may even be said to have contained exceptionally few young elements. Extravasated blood-corpuscles are often present in large numbers, masking the tissue into which they have intruded. Where these are absent, we see a gelatinous, transparent basis-substance, with scattered roundly-polygonal cells of fair size, which, were their locality unknown, might readily be taken for small epithelial elements. These cells are either altered fat-cells, as may be inferred from their occasionally containing a large oil-globule, or they are really elements of recent growth, concerning whose origin we are quite in the dark. Their scanty number, as compared with the amount of basis-substance, does not allow us to assume any active or inflammatory process of proliferation.

The state of the parenchyma is thrown quite into the shade by the striking dilatation and congestion of the medullary vessels. I have already alluded to the constant presence of parenchymatous hæmorrhages in this disease. The medulla owes its dark colour to this extravasated blood and the turgescence of its capillaries. I cannot bring myself, however, to regard this congestion as an active one. It would be in contradiction to the atrophic aspect of the medulla and the total absence of inflammatory infiltration or proliferation. The appearances accord far better with the hypothesis of a passive congestion, approaching the confines of stasis, and so, notwithstanding the excess of blood, causing malnutrition and ultimately degeneration. I am further inclined to assume that an excess of carbonic acid is developed by the blood which stagnates in the medulla, and that this acid may be the solvent which removes the earthy salts from the bone. This may be the missing link between the morbid appearances presented by the medulla and the softening of the bone-tissue. But even assuming that the causal relation between the passive congestion and the softening of the bones were such as I suggest, how are we to account for the congestion itself? Our knowledge of the conditions under which the blood circulates in the bones is still very imperfect. It may be that certain morbid changes in the periosteum are capable of altering the flow of blood through the medulla. The vaso-motor nerves may perhaps be at fault. It has been noticed that the periosteum grows thicker in old people; that it becomes more vascular, and that those vessels in particular, which pass from the periosteum to the surface of the bone, become congested. These changes are associated with a peripheric (so-called "concentric") liquefaction and absorption of the cortical layer of the bone. The sum-total of these changes would make an available pendant to that absorption of bone from within, which occurs in mollities ossium; and this comparison is all the more allowable as we really are acquainted with a senile mollities, differing in no essential point from the usual form of the disease. May we adopt this view, and regard the mollities ossium of young people as a premature senile decay of the skeleton? To this question I cannot venture to return either an affirmative or a negative answer; I prefer to wait, with the reader, the results of further investigation. It is worthy of note that several observers (*Weber*, *Mörs*) have recently succeeded in demonstrating the presence of lactic acid in the urine and bones of patients afflicted with mollities ossium. According to an older observation of *C. Schmidt*, the contents of fully-developed cysts due to softening of bone have an acid reaction. Concerning the source of this acid nothing more is known; it may be that we are now on the point of solving this difficult problem.

§ 669. Let us now bestow a glance on the manifold curvatures and fractures to which the skeleton is liable in osteomalacia. The disease affects by preference the vertebral column and the bones of the pelvis and thorax. The spine is bent into the shape of an S by the weight of the body; a kyphoscoliosis in the dorsal region corresponding to a lordoscoliosis in the loins, while the cervical region projects anteriorly at its junction with the dorsal. The ribs are bent and broken, partly by the traction of the respiratory muscles, partly by the weight of the upper limbs; a line of prominent fractures can be seen not far from the heads of the ribs; a second row of fractures is directed inwards in the axillary line; a third series again projects outwards along the parasternal line. The arms are thus lodged in trough-shaped hollows, the entire thorax being at the same time thrust forward; the sternum, often fractured at several points, is in a line with the chin, which it may even touch. The form of the pelvis is modified under the triple influence of the two heads of the thigh-bones below and the sacrum above. The promontory, and those points of the ileo-pectineal line which correspond to the heads of the thigh-bones, approach each other; while the pubic symphysis, and those points where the ilia are most sharply curved, are thrust outwards or forwards. The pelvic inlet is thus made to assume the shape of a trefoil, beaked anteriorly. In extreme degrees of this distortion, the true pelvis barely allows of the free expulsion of the urine and fæces; to say nothing of the passage of the fœtal head. The bones of the extremities are usually fractured in several places; the fractures being but slowly and imperfectly repaired by the formation of callus. Simple curvatures, such as are common in rickets, are rare in mollities ossium; where a bone appears to be bent at an angle, its deformity is usually due to fracture, complete or partial (§ 636), such as we occasionally meet with in rickets.

§ 670. Recovery from mollities ossium is so very rare that we can only indulge in speculations with regard to the anatomical features of the process. I would not positively affirm that what is known as "cystic degeneration" of the bones is to be regarded in this light; but I would suggest, first, that the formation of cystic cavities in the medullary canal represents an advanced stage in the development of mollities ossium; secondly, that the morbid changes are at an end when this stage is reached. With reference to the former point, I may state that the total liquefaction of the red and pulpy products of softening, which occurs in circumscribed foci, and is the first step towards the development of cysts, may very reasonably be viewed as an ulterior consequence of the profound disturbance in the nutrition of the diseased bone. Of the details of the process we are ignorant; we only know that it results in the production of a clear, watery, highly-albuminous fluid; traces of the intense hyperæmia of the earlier stage of softening being only retained in the yellow and red pigmentary granules, abundantly present in the smaller cysts. The second factor in the "cystic degeneration" is the production of a tough, white membrane of connective tissue which encloses the fluid and shuts it off from the surrounding bone. I have already shown (§ 41) that the bone-tissue itself is capable of undergoing a fibroid metamorphosis, and I do not hesitate to assume that it does so in the present instance. The capsule is only furnished with a few vessels of small size; hence these cysts never take on a secreting character, but remain unaltered for years.

Cystic degeneration usually affects all those bones of the skeleton which were previously affected by mollities. The parts spared by the latter, *e.g.* the sub-periosteal residue of compact tissue which preserves the outlines, at least, of the bone in its papery texture, many of the small bones of the hands and feet, and the entire skull, are also unaffected by cystic degeneration. The cysts themselves are not progressive; hence their development in sufficient number coincides with a real arrest of the disease.

3. TUMOURS.

§ 671. In accordance with the programme laid down in § 609, we shall arrange the many tumours of the osseous system according as they approach or recede from the type of normal ossification. Hence we shall begin with the various bony and cartilaginous outgrowths (*Exostoses* and *Ecchondroses*); next, we shall take the histioid growths and syphilitic formations; and wind up with the carcinomata.

§ 672. The overgrowths of the mature—so-called "permanent" cartilages—are always partial. They usually set out from a small, circumscribed spot of the surface, protruding in the form of warty—and later, of fungoid or polypoid growths (ECCHONDROSIS). We sometimes meet with them on the costal cartilages of people advanced in life, where, however, they do not reach any great size. In close connexion with them stands a group of outgrowths from various synchondroses, and from the intervertebral disks, which have been specially studied by *Virchow*; the most interesting example being the *Ecchondrosis spheno-occipitalis*, partly because of its position on the middle of the *clivus Blumenbachii*, partly because of its minute structure. The tumour is seldom as big as a small cherry, and consists of a soft, tremulous jelly, which turns out, on microscopic examination, to be a cartilaginous tissue whose matrix has undergone mucous softening, while its corpuscular elements have been transformed into large, vesicular cavities (Physalides).

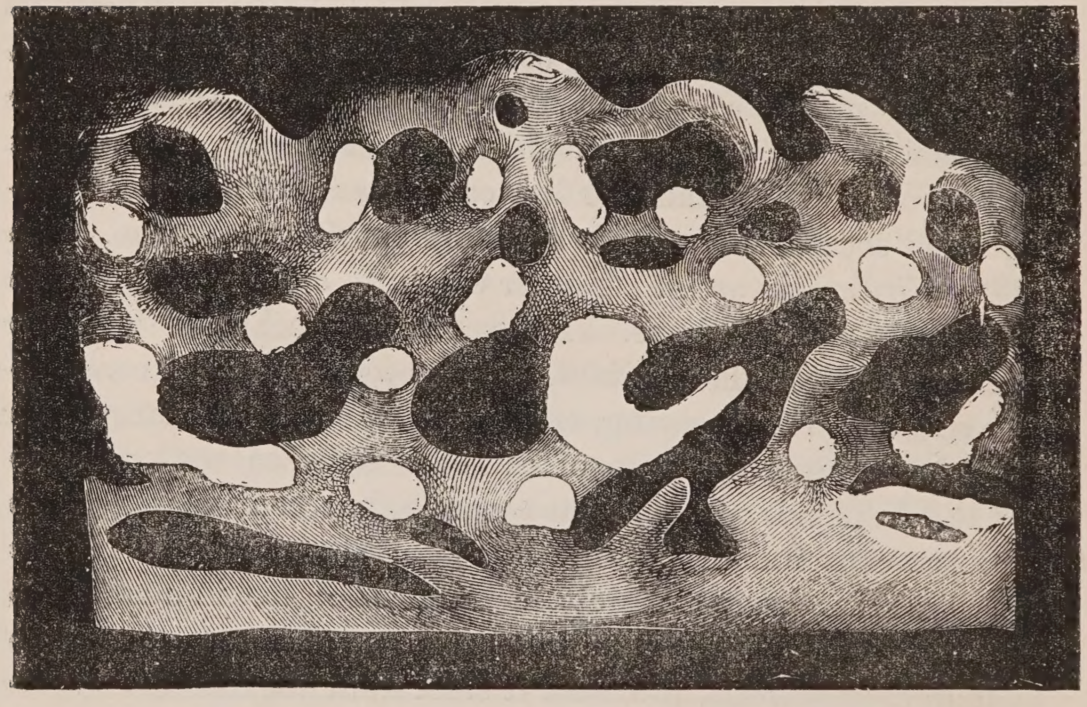
The occurrence of ecchondroses upon the articular cartilages is of more importance. On a former occasion, I described the marginal outgrowth of the articular cartilages in arthritis deformans. In close connexion with this we have, on the one hand, the development of FREE CARTILAGES in the joints, on the other, the EXOSTOSIS CARTILAGINEA. The former are warty outgrowths from the articular cartilages (more rarely from the synovial membrane), as big as a pea and bigger, which have been laced off; they grow in the same place, and consist of the same large-celled cartilage-tissue, as the senile variety of ecchondrosis. They readily become calcareous and are thereby converted into arthrolithes, which may occasion the most serious annoyance to their possessor.

The development of the cartilaginous exostoses (EXOSTOSIS CARTILAGINEA) is rather more complicated; we give this name to certain nodulated outgrowths from the long bones, in the neighbourhood of the joints, which consist mainly of bone, but are furnished with a more or less complete investment of cartilage, and occasionally with a distinct synovial membrane. We follow *Virchow* in assigning their origin to a disturbance in the development of the bone. Here, too, an ecchondrosis is the starting-point of the mischief, but an ecchondrosis of considerable size, which may spring, either from the edge of the articular cartilage, or from the strip of cartilage between the epiphysis and the diaphysis; it does not separate, but continues to grow in permanent union with the bone, thereby causing the latter to increase in size, not merely in the normal, but in a collateral direction which is thus determined for it. It is easy to see how such an ecchondrosis, provided it start from the articular surface and not from the lower edge of the epiphysis, must at first lie in the cavity of the joint itself, then push its way further, first into a protrusion, then into a recess of the synovial membrane, and finally come to occupy a distinct synovial sac of its own (*Exostosis bursata*).

§ 673. We learn from the example of cartilaginous exostosis, how impracticable it would be to separate the hyperplastic conditions of cartilage and bone-tissue from one another. The bone increases in size only because it follows its parent-tissues in their proliferation. These, and not the bone itself, are the really productive elements, the seat of the morbid irritation. This point of view must be strictly maintained even when we consider the EXOSTOSES in the narrower sense of the term; *i.e.* the circumscribed bony outgrowths from the skeleton. They all depend upon some excess of the *periosteal* growth of the bones; and if this circumstance is not indicated in their name, it is only because the periosteum, in contrast to its almost unlimited osteoplastic power, is a very thin, delicate membrane, which strikes the eye but little and is easily stripped off.

The textural changes in the development of exostoses are, saving some subordinate variations, the same as in normal and inflammatory bone-growth from the periosteum. The innermost layer of the membrane yields a vascular embryonic tissue. I have already described (§ 52) how true bone is evolved from this embryonic tissue by the deposit of a homogeneous, dense, highly-refracting basis-substance, calcification, &c. The newly-formed bone is at first extremely porous, and adheres but loosely to the old surface of the bone; it is then termed OSTEOPHYTE (fig. 183): at a later period, the connexion is more close, and then the osteophyte is converted into compact bone-tissue by the concentric addition of fresh bony lamellæ to its trabeculæ. It must, however, be noted that this last change may be deferred for a long time—may, indeed, not occur at all.

FIG. 183.

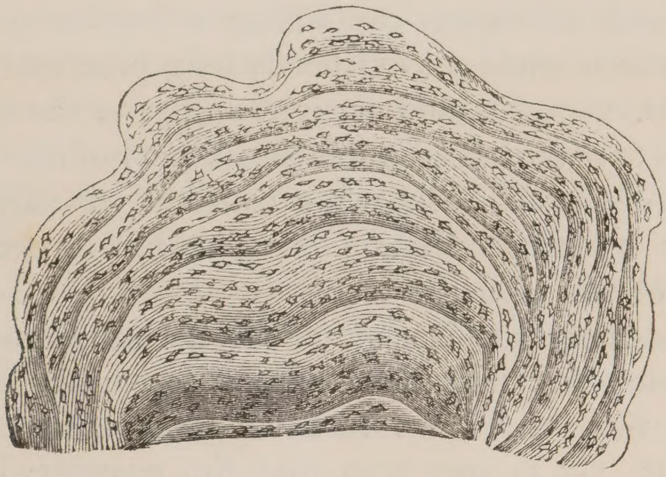


Osteophyte. Periosteal bone-formation in the first or spongy stage.

The "compact" stage is usually followed, just as in normal bone, by a renewed porosity or "sponginess," as we now call it.

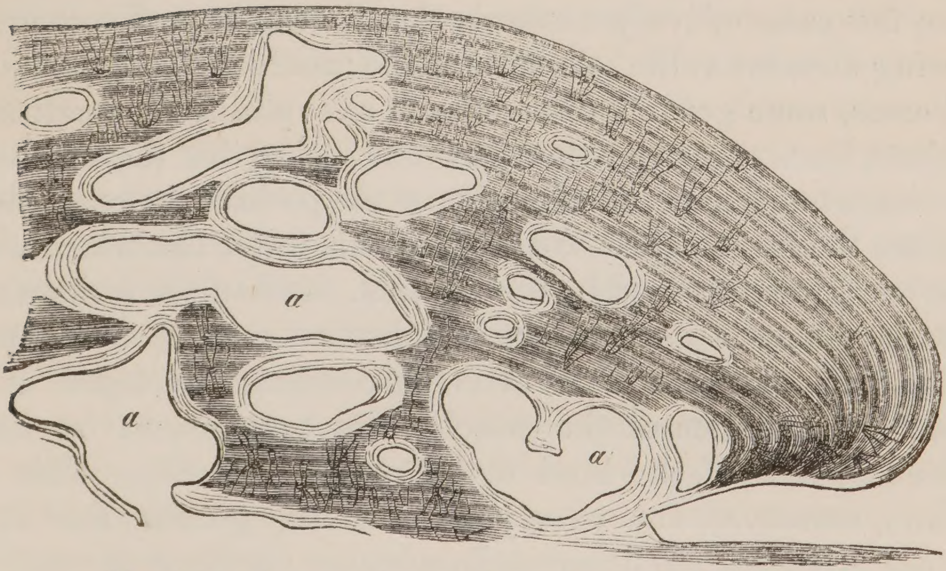
The latter sets in after a certain time with such regularity and constancy, that one might almost be tempted to think that compact bone-tissue, like cartilage, could not exist in layers of more than a certain definite thickness, did not the history of IVORY EXOSTOSIS (*E. eburnea*) prove the contrary. This exostosis is remarkable for its entire deviation from the usual type; layer on layer of bone-tissue being deposited round a minute, nodular protuberance, without any reference to the vessels or their mode of distribution. This is gradually converted into a warty, polypoid, cauliflower-like, white and lustrous formation, which may attain the size of a man's fist, and nevertheless consist throughout of compact bone-tissue (fig. 184).

FIG. 184.



From an ivory exostosis of the scapula.

FIG. 185.



Exostosis eburnea clavata, from the roof of the skull.

This mode of development undoubtedly recals that of the dental cementum; and the analogy is still more striking in the case of those peculiar, small, round and flattened outgrowths from the roof of the skull, which look like ivory shirt-studs, and have accordingly been termed BUTTON-LIKE EXOSTOSES by *Virchow*. A vertical section through the middle of one of these growths (fig. 185) shows that its marbled tracery is due to a finely striated substance, containing a bone-corpuscle at rare intervals, which sends out extremely long processes in one direction only, *sc.* outwards, and at right angles to the striæ. Is not this enough to make us recognise the identity of this fundamental constituent of the exostosis, whose continuity is only interrupted secondarily by the formation of medullary spaces, with the cementum of the teeth?

§ 674. Among the causes of the periosteal overgrowth of bone, inflammatory irritation takes a foremost place, in comparison to the simple, *i.e.* hitherto unexplained, anomaly of development. It is very true that the growing bone is especially predisposed to these, as to other alterations—but advanced age and heredity also involve a like predisposition; and it is only in a few cases of ivory exostosis that we can regard this predisposing element as the sole cause of the mischief. In the majority of cases, some general disease, such as syphilis, rheumatism, or rickets, has a part in its causation; and seeing that these disorders are known to excite inflammation of the periosteum very readily, we are the less entitled to disregard this latter fact where we see the overgrowth caused by an external, mechanical irritant. A knock or blow is often assigned as the first cause of an exostosis; more than one case of MULTIPLE EXOSTOSIS, developed at the points of insertion of the muscles, has been placed on record (the last case of the kind by *Virchow*, *l.c.* ii. 84). This case shows, moreover, how closely inflammatory growth, due to external irritation, and non-inflammatory, normal growth, are related to each other. For the normal skeleton also exhibits rough projections, corresponding to the insertion of a great many muscles—projections known in descriptive anatomy as *cristæ*, *tubercula* and *eminentiæ*.

§ 675. While, as we have seen, exostoses and ecchondroses only present insignificant deviations from the normal course of development in bone and cartilage, the histioid tumours of the skeleton can only be referred to physiological types by way of analogy. We may lay stress on their point of origin, which may be either in the periosteum or in the medulla, agreeing in this respect with the two modes of normal growth; and we may accordingly distinguish between central and peripheric sarcomata, enchondromata, &c. Further, in all the peripheric species, we can distinguish a preliminary stage, during which the morbid proliferation does not differ outwardly from that periosteal proliferation which ushers in the development of normal bone; moreover, we can trace an analogy with the physiological properties of the periosteum, in the especial proneness of these tumours to become ossified. Finally, the "*Chondroma osteoides*," described in § 139, obviously comes very near to the physiological type. Still, we ought chiefly to lay stress on the heterologous character of the new growth, regarding all sarcomata, enchondromata, myxomata, &c., of the skeleton, as qualitative departures from the laws regulating the productive function of the conjoint vascular and connective-tissue system.

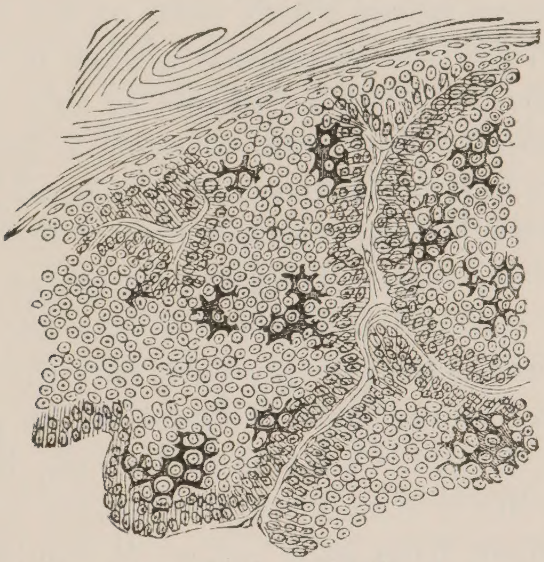
§ 676. Taking first the PERIPHERIC OSTEOSARCOMATA, we find the soft layer of the periosteum, which lies next the bone, and which *Max Schultze* has so aptly called the "cambium-layer," mainly involved in the production of this kind of tumour. Indeed we may conceive the development of the sarcoma to be ushered in by a quantitative excess in the phenomena of normal growth proper to this region—especially by the production of a larger amount of embryonic tissue over a circumscribed patch of the surface of the bone. In its later stages, peripheric osteosarcoma is simply a sarcoma situated between the periosteum and the bone. Quite apart from its clinical history, from the metastases and relapses which it occasionally exhibits in their most striking forms, a very superficial histological analysis is enough to disclose the sarcomatous nature of the tumour. It usually contains all the varieties of sarcoma-tissue side by side; yet spindle-cell tissue predominates in most cases. This is particularly true of those enormous tumours which are developed on the ends of the great bones of the extremities (femur, tibia, humerus, &c.), and are characterised by their imperfectly radiating structure. They detach the periosteum, overlap the adjacent cartilage, and penetrate but a little way into the compact tissue of the cortex. At a later stage, they invade those structures which are continuous with the bone, *sc.* muscles, parosteal connective tissue, capsules of joints, ligaments, &c., while those which lie more loosely on the surface of the growth, *e.g.* bellies of muscles, and tendons, give rise to corresponding grooves upon it.

In all sarcomata of the bones, whether they spring from the medulla or the periosteum, we occasionally come across bits of bone-tissue of various sizes which are developed secondarily; as a constant occurrence, however, ossification is restricted to a single division of the peripheric osteosarcomata, which have been termed "osteoid" tumours by *Joh. Müller* for this very reason. *Müller* distinguishes between a benign and a malignant form of osteoid. The latter is identical with the "cancer of bone" which will hereafter be described. We will confine our attention at present to the former variety. The benign osteoid, which usually affects the bones of the face, exhibits, as a rule, a markedly radiating structure. From a single point, or rather from a relatively small surface, fibrous bands, which can be distinguished even by the naked eye, radiate uniformly and in straight lines towards the periphery; moreover the tumour can be torn in these directions more readily than in others. This is due to an almost papillary composition of the mass, which consists of long, thin papillæ, giving off branches at very acute angles. Fig. 186 (a horizontal section) shows that the papillæ are, upon the whole, round, consisting throughout of embryonic tissue with a scanty intercellular substance. Bands of lax connective tissue traverse the interstices between the papillæ and fill them up. It is worth noticing that lacunar fissures are visible here and there between the sheaths of connective tissue and the surface of the papillæ. The two present smooth surfaces to each other at these points; the fissures can readily be filled with injection, and communicate with neighbouring lymphatics.

§ 677. The subsequent ossification is merely a calcification of the scanty intercellular substance. A circular, not always stellate, lacuna, takes the place of each corpuscular element (fig. 186); the mere texture of the parts would not of itself induce me to call the process one of true ossification, were it not for the fact that the earthy salts are deposited in zones in the interior of the papillæ—zones which invest the blood-vessels, and so betray their analogy with osteophytes. After maceration, the ossified parts of the tumour are seen to form a radiating framework, loosely built up of thin trabeculæ of bone.

I have seen an exquisite example of peripheric osteosarcoma, consisting throughout of round-cell tissue, and nowhere presenting any trace of ossification; the specimens are now in the Zürich collection. At various points of the skeleton, especially on the sternum, the inner surface of the skull, and at all those foramina in the skull and spinal canal through which nerves enter and make their exit, the periosteum was detached by a layer of substance like fish-roe; this layer was only a line thick for the most part; over the sternum, however, it was as thick as the finger. The superficial extent of these multiple sarcomata varied between the limits of a lentil and a dollar-piece; at the points of exit of the nerves, the sarcoma formed circular cushions, particularly at the intervertebral foramina.

FIG. 186.



Transverse section through the middle of an ossifying sarcoma, growing from the periosteum of the lower jaw. It is a round-cell sarcoma, with its basis-substance calcified in parts. The calcified portions form elongated splinters, perpendicular to the surface of the bone, and which are therefore seen in transverse section. $\frac{1}{300}$.

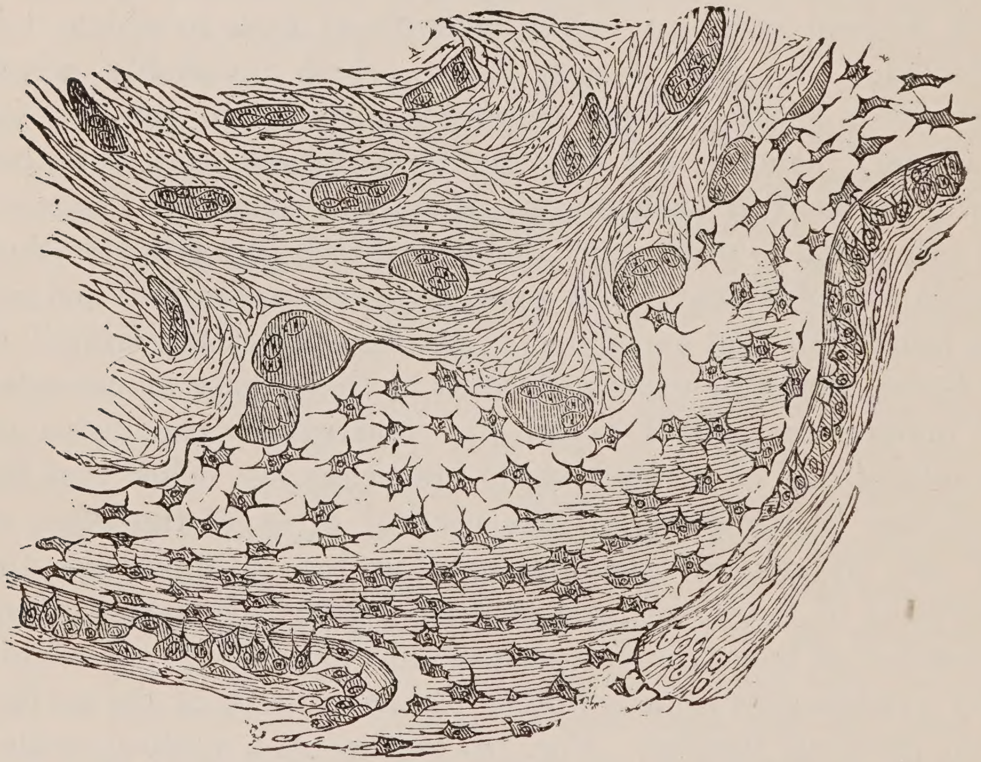
The naso-pharyngeal polypi which spring from the anterior surface of the upper cervical vertebræ and *os tribasilare*, must be viewed as purely fibrous sarcomata of the periosteum. (Cf. *Virchow*, Geschwülste, i. p. 354.)

Whether it be possible for giant-cell sarcomata to spring from the periosteal covering of the bones, has not been, in my opinion, clearly made out. *Virchow* has recently included those tough and elastic, more rarely soft, sarcomata of the alveolar processes, which are attached by a broad base and form rounded protuberances (long known as *épulides*), among peripheral osteo-sarcomata in the sense of periosteal proliferations. In this matter he is opposed to *Nélaton*, who, though also contrasting two groups of "myeloplaxic tumours" (giant-cell sarcomata) *sc.* the *épulides périosseuses* and the *épulides intraosseuses* with one another, makes the former variety spring, not from the periosteum directly, but from the perivascular medullary cells of the dilated Haversian canals which open on the surface of the bone. *Nélaton* wishes the giant-cells always to be recognised as medullary elements. *Virchow* objects to this, that many of the *épulides periosseuses* are situated upon a bony eminence, which he believes to be an antecedent periosteal proliferation, and which intervenes between the soft part of the tumour, with its giant-cells, and the bone. True, he also recognises the great proneness of the epulides to penetrate into and destroy the bone; I feel inclined to ask, for my part, why the bony basis in question should not be regarded as a part of the growth itself, which has become ossified. On this hypothesis, it would serve rather to indicate the continuity of the tumour with the bone, than to separate them from each other; it would thus favour *Nélaton's* view. I speak with caution on this point, because I have assured myself, in connexion with those giant-cell sarcomata which spring from the medulla, that the giant-cells are really bone-corpuscles which have been set free during the absorption of the bone-tissue, and have then entered upon this peculiar state of hypertrophy. This, of course, must not be taken to mean that giant-cells cannot originate in other ways as well. (Cf. § 67.)

The sarcomatous epulis contains giant-cells of enormous size. When these drop out of fine sections cut parallel to the edge of the jaw, gaps are left, which are not unlike the alveoli of cancer. The quasi-stroma is made up of the various species of sarcoma-tissue, and the tumour is harder or softer, according as one or other species predominates in its composition. The firmest tumours are chiefly made up of connective-tissue fibres, the softest of round-cells; those of medium consistency (which are also the most usual ones), of spindle-cells.

§ 678. CENTRAL OSTEOSARCOMATA (Myelogenic Osteosarcomata, *Virchow*) occur in three forms. The most common variety is the giant-cell sarcoma of the lower (more rarely of the upper) jaw, called *épulide intraosseuse* by *Nélaton*. It springs from the red marrow of the cancellous tissue, and continuing to increase by central growth, forms irregularly rounded masses, which may reach the size of a child's head. It is obvious that during this enlargement they must come into conflict with the compact cortical tissue of the bone. The cortex of the bone is "expanded" by the tumour from within; this is the generally received view, which our first glimpse of the tumour apparently confirms. It seems as if the bone lacked its characteristic hardness and density, and were compelled to yield, without resisting, to the centrifugal force to which it is subjected. The phenomenon is one which invariably recurs whenever a slowly-growing tumour is situated in the interior of a bone; it recurs, not only in all myelogenic sarcomata, but also in the central enchondromata and myxomata. *Volkmann* has attempted to prove that the bone-tissue is really stretched (innere Verschiebung); but even his acute reflections and my own conviction that every one of the cases of "stretching" of the bones, which he examined, must be thoroughly investigated and taken into account, before any trustworthy conclusion on the subject can be arrived at, do not shake my belief that the expansion (Aufblähung) of the cortical layer of the bone, at any rate by central osteosarcomata, is due to apposition and absorption of tissue. Apposition from without—by a continuous production of bone from the periosteum; absorption from within—by a continuous liquefaction of the bone-tissue at the surface of the growing tumour. Fig. 187 represents a vertical section from a myeloid tumour as big as a man's fist. It includes the edge of the tumour, and a trabecula of bone, which, together with three or four others of exactly similar texture, represents the last remnant of the bony cortex of the lower jaw. This trabecula exhibits both changes in progress. The side turned towards the periosteum is almost entirely beset with the well-known "osteoblasts" of *Gegenbaur*. The opportunity for seeing the way in which bone-tissue is formed is most favourable; every step of the process is presented with unrivalled clearness (§ 52). On the opposite surface of the trabecula absorption is going on. A sharp, arcuate line limits the bone at its junction with the tumour. At several points, multinuclear giant-cells are seen lying in the depressions formed by Howship's lacunæ; the size of these giant-cells varies; the smallest ones are only a trifle larger than the adjacent bone-corpuscles, and would hardly deserve their name, did they not betray themselves as future "myéloplaxes" by the uniformly granular character of their protoplasm, and the presence of intermediate forms. The youngest "myéloplaxes" are so constantly situated at the inner edge of the bone that it is impossible not to believe them to have originated here, perhaps by a metamorphosis of the bone-corpuscles set free from time to time by the advancing liquefaction of the basis-substance of the bone. Now on comparing the distribution of the giant-cells in the sarcoma with that of the bone-corpuscles in the bone, it is impossible not to be struck by the fact that both the one and the other set of elements are disposed alternately, at regular intervals,

Fig. 187.



Fragment from the edge of a spindle-cell and giant-cell sarcoma of the lower jaw, as large as a closed fist. Trabecula of bone, which is disappearing by absorption on one side, while on the other it is growing by apposition of new tissue. For details *see* text. $\frac{1}{500}$.

in their respective tissues. This coincidence, however, seems to be very simply explained by the hypothesis that during the growth of the tumour the bone-corpuscles which are set free and forthwith converted into "myéloplaxes," are pushed away from the bone and incorporated into the tumour with a certain degree of uniformity, by cellular layers belonging to the growth itself. This, of course, does not prove conclusively that the giant-cells of the central osteosarcoma are former bone-corpuscles. Meanwhile, I am happy to say that the physiological occurrence of giant-cells has recently been explained on this very theory (*Bredichin*, Centralblatt, 1867, 563).

So much for the histology of the "expansion" of bone. It is obvious that even if apposition keep pace with absorption, a thinning of the shell of bone must occur in time. It is necessary that more bone should be added than is absorbed, if the bone is to invest the continually growing tumour with a layer of compact substance of unvarying thickness. Since, however, the contrary is rather the case, *i.e.* less bone is added than absorbed, we cannot be surprised to find the shell ultimately deficient in parts —to find the tumour perforating the bone.

The intra-osseous epulides of the jaws, which we have been hitherto considering, consist mainly of spindle-cell tissue. The tendency of the cut surface, when fresh, to assume a yellowish red or even greenish hue by exposure to the air, is noteworthy.

§ 679. The second kind of central osteosarcoma is principally met with in the lower end of the femur, the upper end of the tibia, and the upper end of the humerus. It is remarkably soft and vascular. The round-cell tissue of which it primarily consists is developed at one point into mucous tissue, at another into adipose tissue, at a third into spindle-cells and fibrous bands; the tumour is thus rendered compound (*Sarcoma mixtum*). Its vascularity often leads to hæmorrhages, whose effects, in the form of recent coagula, or of older "foci of softening" crammed with reddish-brown pigment, may mislead the observer at the first glance, making him believe that he has to do with an aneurism of the bone or a fungus hæmatodes. The latter term is of course the only one which can legitimately be applied to the growth; and even that with caution. This tumour, like the last, is distinguished by containing multinuclear giant-cells; it must therefore be classed with the giant-cell sarcomata.

§ 680. Thirdly, we have a central osteofibroma, whose close affinity to the "épulides intraosseuses" is shown by its predilection for the jaw-bone, and the exactly similar way in which it expands the cortex. No giant-cells have been detected in it. On the other hand, it is singularly prone to undergo ossification; we either find a number of small bony splinters in its interior, giving a gravelly roughness to its cut surface, or ossification on a vaster scale may gradually convert the whole tumour into an osteoma.

§ 681. Pure MYXOMA of the bones is described by *Virchow* as a growth starting from the marrow, distending the bone and finally breaking through it; its texture resembling the flesh of an oyster, or the jelly-like disk of a medusa. Owing to the close relationship between myxomata and enchondromata, it is difficult to draw a sharp line between them. Most of the soft and jelly-like tumours of the bones are enchondromata.

§ 682. I have already said, in speaking of the general histology of ENCHONDROMATA (§ 135), that they are usually seated in the bones. I may now add, that of the various parts of the skeleton, the phalanges of the fingers and toes are the most often affected; next come the humerus, femur, and tibia; next the jaws, pelvic bones, and scapula; the ribs and the basicranial bones are more rarely involved, the vertebræ, clavicles, and sternum most rarely of all. *Joh. Müller* originally divided enchondromata into those which are external and grow from the periosteum, and those which are internal and set out from the medulla. But here we are met by the same difficulty as in the case of the epulides; there is no question about the internal variety—but with reference to the external one, it is impossible to be sure how far the compact substance of the bone, and how far the periosteum has a share in their production. Even *Virchow* is in doubt upon the subject. To add to our perplexity, a direct transformation of bone-tissue into cartilage has lately been asserted to be possible by several observers (*Weber*).* The compact tissue would thus claim more attention at our hands, more especially if *Virchow's* suggestion should be confirmed, *sc.* that residual portions of cartilage, forgotten in the compact tissue, may give the impulse for enchondromatous degeneration.

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* The progress of this change can only be studied in very thin lamellæ of bone, taken from the boundary between the bone and the tumour. The bone-tissue undergoes a sort of uniform liquefaction; its basis-substance grows translucent from its edges, while the corpuscles lose their processes, and come to lie in rounded cavities, seemingly produced by a mere softening of the basis-substance, which sets out from the lacunæ, and

The internal variety of enchondroma resembles the central osteosarcomata and myxomata only so far as it expands the bone into a mere shell, only breaking through it here and there after it has lasted a long time. In other respects, the growth of an enchondroma by foci disseminated through the tissue round it, is the cause of some very remarkable peculiarities. Among these, I may particularly allude to the more intense irritation caused by the production of scattered nodules round the primary tumour. Besides an ossifying periostitis, often on a considerable scale, we often find a true ossifying osteomyelitis. The medullary cavity in the neighbourhood of the enchondroma, often seems to be quite shut off by a very dense, finely-porous, compact substance. The ossifying periostitis continues to furnish layer after layer of new bone, thereby adding fresh materials for the building up of the tumour, and producing a bony capsule, which does duty for a longer time in the enchondromata than in any other of the central tumours of bone.

Enchondromata of the bones last longer and grow bigger, without undergoing any internal change, than enchondromata of the soft parts. In a later stage, they exhibit the secondary metamorphoses described in § 137, *sc.* calcification, ossification, conversion into mucous tissue, mucous softening, and cystic degeneration. It only remains for us to mention several varieties of enchondroma which have hitherto been met with only in the bones.

a. *Enchondroma hæmatodes.* On the right fibula of a boy admitted into the surgical wards at Bonn, there was a tumour as large as two fists, which was undoubtedly cartilaginous at its periphery, and betrayed the lobular structure characteristic of an enchondroma. But the central lobules presented a gelatinous and swollen condition of their basis-substance, and were

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is restricted to their immediate neighbourhood. It cannot be denied that bone-tissue, in this stage of its metamorphosis, presents a great similarity to cartilage; yet the process, as a whole, does not give one the idea of a proliferation, but rather of an organic metamorphosis—not, of course, synonymous with disorganisation.

permeated by blood-channels of a very peculiar kind, concerning whose nature only one definite assertion could be made, viz. that they had been produced by the anastomosis of contiguous cartilage-cavities. They formed a network with well-marked nodal points, whose edges were concave inwards. Whether they really were blood-vessels, or whether the case was simply one of extravasation modified by the peculiar structure of the parts, we were not able to decide. The softening was associated with a simultaneous sarcomatous degeneration of the skeletal framework of connective tissue (*C. Höstermann*, Inaug. Dissertation, Bonn, 1868).

b. *Enchondroma pseudopapillosum.* A peripheric enchondroma of the upper jaw, also obtained from the clinical wards of Geheimrath *Busch;* its surface was distinctly papillose—beset with cauliflower excrescences. The massive proliferation, after filling up the antrum, had perforated the bone anteriorly. The tumour owed its singular structure to its marked central growth, which formed a striking contrast to that of the proper enchondromata. The smallest nodules were continually reproduced in the connective tissue of the larger ones. At last, the independent growth of the latter partially detached the tumour from its environment. It was broken up and dismembered into groups of nodules by horizontal clefts and fissures—into groups very like the branched papillæ of a cauliflower growth. (*C. Hopmann*, Inaug. Dissert., Bonn, 1867.)

§ 683. Cancer of bone will soon be an urgent question in pathological histology. If it be true, as *Thiersch* and his ardent followers assert, that all true cancers set out from the superficial or from the glandular epithelium, it is plain that all cancers of bone must originate by a propagation of the infiltration from cutaneous, mucous, or glandular cancers in their neighbourhood. This is undoubtedly often the case. *E.g.* when we see an epithelioma of the face propagated to the jaw-bones, or an epithelioma of the leg to the tibia—setting up a kind of cancerous caries in these bones, what happens is this: cylinders of cancer-cells are protruded into the vascular pores of the bone, which increase proportionately in size, while the intermediate "territories of nutrition" disappear. So too, when metastatic nodules crop up and thrive in the diploë of the cranial bones, or in the spongy substance of the ribs, or in the medulla of the bones elsewhere, we may at any rate admit the possibility of an "epithelial infection" of the local medullary cells, even though, as an anatomist, I should have in that case simply to concede that connective-tissue corpuscles may be converted into epithelial cells, and that cancer may thus be developed from connective tissue. But how are we to evade the necessity for recognising that there also exist cancers of bone which are primary, and which, moreover, show a distinct tendency to recur in the same place and in the same form? First, we have those soft and quickly-growing cancers which are so prone to spring from the upper end of the humerus or the femur, occasionally arriving at an enormous size. They are mainly developed, now from the medulla, now from the periosteum; no sooner is the latter involved, than the growth of the tumour proceeds wtth accelerated velocity, while ossification sets about constructing an extremely beautiful, spongy or radiating framework. It is always the thicker trabeculæ of the cancer-stroma which become calcified, and so furnish a kind of spurious bone-tissue (*carcinoma osteoides*). A second, and equally favourite seat of primary cancer, is in the bones of the skull. Soft, rapidly-growing nodules spring up in the diploë and speedily perforate the cortical layer in both directions. Or else the central tumour may increase somewhat more slowly, and the periosteum has time, at any rate to begin the formation of a shell. This may occasionally be seen in the upper jaw. A third, less usual, but all the more characteristic variety, is the diffuse carcinosis of the pelvic bones and adjacent vertebræ, which presents the clinical features of osteomalacia. Here too, the disease is a soft cancer, distinguished by the degeneration of the medulla starting from a countless number of minute foci. In all these primary cancers of the bones, there cannot be any question of an epithelial origin; and yet our whole conception of cancer would have to undergo a revolution, were we to exclude these growths from its domain.*

We are still in need of fuller data concerning the origin of the first cancer-cells; the analogy of the other myelogenic tumours of bone points to a metamorphosis of the medullary cells—and, as I add with emphasis—of the corpuscular elements of the perivascular adventitia. The bone-tissue melts unresistingly before the advancing growth. Its absorption is usually preceded by a decalcification, just as in osteomalacia. The trabeculæ of the bone are thus—at one stage—elastic and flexible, like cartilage. The behaviour of the bone-corpuscles is probably not the same in all cases. It is comparatively easy to break a splinter of bone from the middle of a cancerous tumour, and to investigate it with reference to this point; so that I am able to refer to a considerable number of such observations. They go to prove that it is only by way of exception that any active participation of the bone-corpuscles in the growth can be detected. The annexed drawing (fig. 188) shows how they may take part in the process. The specimen was taken from the edge of a soft cancer of the ribs. One of the trabeculæ which surround the growth has been invaded by it and wholly dissolved on one side, while on the other, its edges are still smooth. The bone-corpuscles, which still continue normal on the side turned away from the tumour, increase steadily in size, while the basis-substance loses its earthy salts and shrinks, in exact proportion to the increase in size of the corpuscles. On this side of the trabecula, only a scanty residue of it can still be seen. The corpuscular elements, on the other hand, have been transformed, by fission of their nuclei and augmentation of their protoplasm, into multinuclear elements of larger size, which are speedily broken up into as many smaller cells as there are nuclei. Whether these cells afterwards become cancer-cells or whether

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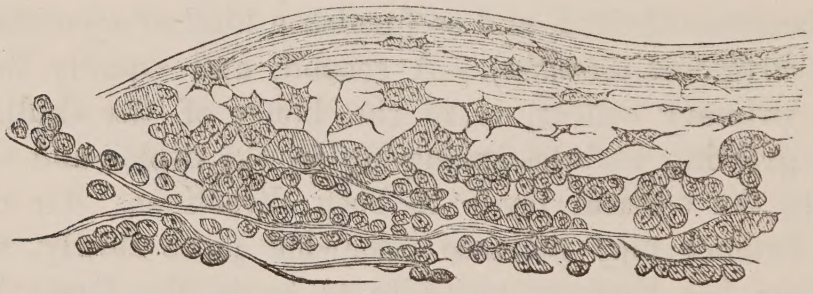
* In a paper recently published in Langenbeck's Archiv, *Billroth* suggests that certain varieties of soft cancer ought to be regarded as alveolar sarcomata, due to a higher evolution of the lymphadenoid type of tissue; this idea seems to me to apply most admirably to sarcomata of the bones and nerves.

Fig. 188.



Trabecula of bone undergoing cancerous degeneration. $\frac{1}{500}$.

their production is not merely a collateral effect of the intense tissue-irritation, I must leave undecided. The phenomenon itself is not a constant one.

Colloid cancer has also been repeatedly met with in the bones—though always in a secondary form. But there are no histological observations on record concerning its origin and mode of extension.

§ 684. SYPHILITIC GUMMATA make their appearance in the skeleton during the so-called "tertiary" stage of the disease. The term "gumma" is probably derived from the peculiar sense of elastic resistance communicated to the finger, when we explore the flat, circumscribed swellings of the cranial bones through the integuments of the scalp. The soft, rapidly proliferating tissue of which these tumours are composed, is primarily furnished by the innermost layer of the periosteum; at this point we are once more reminded of physiological growth; but in the very next stage, the minute texture of the morbid product is heterologous throughout. A delicate, gelatinous, in some parts fibrous basis-substance, contains a number of round and spindle-cells, beautifully arranged in concentric rings round the vessels which traverse the new formation in all directions. I regard these vessels as the periosteal vessels of the bone—those which normally cross the interval between the periosteum and the bone, and dip into the superficial layers of the cortex. The adventitia of these vessels is the proper matrix of the syphiloma. It is here that cells and basis-substance are produced in successive layers, the younger ones pushing the older ones before them, and so causing a concentric arrangement of the entire texture of the morbid growth. The mucoid swelling of the basis-substance developes mechanical forces, with which neither the bone nor the periosteum are fitted to cope. The latter is stripped from the bone, the former wastes under the pressure of the tumour, becomes rough, and finally exhibits deep defects (*Caries syphilitica*). Meanwhile, the syphilitic infiltration creeps along the Haversian canals into the compact tissue of the bone, destroying it territory after territory, just like the medullary granulations in rarefactive ostitis. When once the bone-tissue between any two vessels is wholly destroyed, the syphilomatous masses from either side coalesce, and the primary implication of the perivascular sheaths is only indicated by the concentric grouping.

We shall see an exact repetition of these conditions in gummata of the brain.

Syphiloma of the bones must be viewed as itself a heterologous, syphilitic inflammation, while, on the other hand, it excites all forms of ostitis and periostitis in its neighbourhood, by which the bone is more damaged and distorted than it is by the tumour itself. Syphilitic inflammation, caries, necrosis, &c., are not texturally different from the simple varieties of the same affections. Syphilomata are liable to undergo caseation; a direct liquefaction into pus has also been observed. Under the influence of antisyphilitic remedies, the mucus of the basis-substance undergoes a chemical metamorphosis of another kind, which fits it for being reabsorbed, while the cells are converted into *débris*, also capable of being taken up into the blood.

§ 685. If we exclude the cases of caseous ostitis which have already been described from TUBERCULOSIS of the bones, the only true miliary eruption which remains is an occasional, rather uncommon appearance in the neighbourhood of the cheesy deposits. According to *Virchow*, the tubercles originate in the red marrow, and do not differ in structure from the ordinary type of miliary nodule. For my own part, I have never had an opportunity of seeing true tubercles in bone.

XVII.—MORBID ANATOMY OF THE NERVOUS SYSTEM.

§ 686. One of the most striking features in the pathological histology of the nervous system, is the trifling and always passive share taken by the proper nervous elements in all those changes which affect the brain, spinal cord, or peripheral nerves. As every effort has been made to refer the diseases of the nervous system, and particularly psychical disorders and other essential neuroses, to morbid changes in the ganglion-cells and nerve-fibres, we may, with perfect confidence, supported by the negative result of all such investigations, maintain the thesis, that the causes, perhaps of all (?) diseases of the nervous system, are to be sought in anatomical lesions of the non-nervous elements. Bearing this in mind, however, it seems advisable to begin with a few introductory observations concerning the many ways in which the nervous and non-nervous elements take part in the composition of the various sections of the nervous apparatus.

§ 687. We may start from the position, that the finest ramifications of the peripheric nervous system—the solitary nerve-fibres—are embedded in that continuous mass of connective substance which fills up all interstices between the organs and the component parts of organs, throughout the body. Even after the ultimate fibres unite to form bundles of about twenty each, we cannot detect any appreciable modification in the quality of the connective tissue. In harmony with this is the unconstrained course of the individual fibres, their incessant twisting and bending, the peculiar laxity of texture which characterises these smallest nerve-bundles. On passing, however, to the larger trunks, we find a very marked differentiation of the connective tissue *between* the nerve-fibres from that which *surrounds* them. The softer and more delicate the former, the so-called "perineurium," the more dense does the latter become, forming a tough sheath well fitted to protect the nerves from mechanical disturbance. The perineurium contains no true fibrillæ of connective tissue ; its intercellular substance is homogeneous, and, but for the presence of corpuscular elements, would not be visible at all. The cells have elongated nuclei, surrounded by a very small quantity of finely-granular protoplasm. Whether the sheath of *Schwann* in the medullated nerve-fibres, forms part of the fibres, or of the perineurium, I will not take it upon me to decide; I would only remind the reader that the structures, sometimes called the "nuclei of the sheath of *Schwann*," are identical with the corpuscular elements of the perineurium, since, by taking part in every pathological proliferation of the interstitial connective tissue, they spontaneously identify themselves with it.

The outer sheath of the peripheral nerve-fibres contains the trunks of the vessels which nourish the nerve-tissue ; it sends a certain number of fibrous prolongations inwards, which divide the nerve-fibres into fasciculi of various sizes, and carry the smallest venous and arterial twigs, while the elongated meshes of the capillary network are spread out in the perineurium.

In the central organs of the nervous system we find a still further specialisation of the non-nervous elements. In the brain and spinal cord, the perineurium assumes a peculiar delicacy, while the outer investment of connective tissue is differentiated into an external, very dense, thick and tough membrane (dura mater) containing only a few slender vessels, but all the more fitted to protect the nerve-centres, and a very delicate layer of lax connective tissue (pia mater) which must be exclusively regarded as the vehicle of the larger blood-vessels. The processes of connective tissue along which the smaller vessels pass into the interior of the organ, are still to be seen in the cord; indeed the white substance of the cord differs but little, upon the whole, from a peripheral nerve in *quality*. In the brain, on the other hand, the smallest arteries and veins are usually said to penetrate quite "naked" into the holy of holies of the nervous system. We must not interpret this "nakedness" too strictly; indeed it would be quite inexcusable for any one familiar with the morbid anatomy of the brain to overlook the sheath of connective tissue, however slender, by which these vessels are surrounded. The structure in question has been described either as a tunica adventitia, or as a perivascular lymphatic tube. *Kölliker* was the first to strip a homogeneous membrane, with nuclei upon its inner surface, from the cerebral vessels; *His* afterwards proved by injection, that this membrane was separated from the brain-substance by an interval communicating with larger perivascular spaces in the pia mater. *His* believes that all these spaces are lymphatic canals. I admit his hypothesis, with the express reservation that these "lymph-paths" are far from exhibiting all the characters of true "lymphatics." Their endothelium is, to say the least, imperfect; their walls are incomplete; indeed we ought simply to speak of "interstices in the connective tissue;" and it would probably be most correct to include the whole arrangement among those "cellular" spaces, which formerly caused the intermuscular and subcutaneous connective tissue to be known as "cellular tissue." Their only special feature would in that case be their continuity with the lymphatic system, a continuity which is still far from having been satisfactorily demonstrated.

To conclude with a few words about the perineurium of the brain, the "neuroglia" of *Virchow*. Neither the precise nature nor the quantity of this substance have as yet been adequately ascertained. As regards its nature, a distinction is usually drawn between the neuroglia of the white, medullary substance, and that of the grey, ganglionic, cortical layer. As for the neuroglia of the medullary substance, we may safely affirm that it comprises whatever elements are met with in the white matter, apart from nerve-fibres and blood-vessels; hence all the granules and nuclei in the white substance are neuroglia-cells and nuclei—hence the white, finely-granular, and spongy material, in which the nerve-fibres are embedded, is the basis-substance of the neuroglia. In the case of the cortex, it is much harder to arrive at a decision. At the cortico-medullary junction in the cerebellum, and less strikingly in the cerebrum, we come upon a crowd of so-called "granules," *i.e.* of small, pale, round, homogeneous, quasi-nuclear bodies which, according to recent investigations, are collectively equivalent to minute cells, since they are all provided with little appendages of protoplasm—a fact which had formerly been overlooked. These appendages are sometimes produced into slender threads; hence it has been supposed that the granules are continuous with nerve-fibres and therefore themselves nervous elements. They diminish in number towards the surface, though still tolerably frequent—in little groups of from three to five; besides them, we have the well-known pyramidal ganglion-cells; but the main bulk of the grey matter is made up of a continuous mass of very finely-granular, and—according to the views of *M. Schultze*, now generally received—minutely reticulated and spongy substance. This substance, obviously destined to support the nervous elements, is the basis-substance of the neuroglia; we have only to ascertain which of the corpuscular elements contained in it are to be viewed as the neuroglia-cells. Were we simply to transfer the experience derived from the white to the grey matter, we might summarily assign the character in question to some part, at least, of the granules. I know of no difference between the "connective-tissue granules" of the white, and those of the grey matter. But here we are confronted by the belief of distinguished authorities (to which allusion has been already made), that the granules of the cortex are really minute nerve-cells. Pathological phenomena do not resolve the problem satisfactorily; for although we are able to prove that certain tumours originate and grow by the proliferation of these cells (Gliomata), we are at once met by the difficulty, that these very tumours do not occur elsewhere, with the sole exception of the retina, whose structure is closely related to that of the nervous centres. All other morbid growths and products, such as cancer, sarcoma, tubercle—even pus itself—originate in other ways; their evidence is only of subordinate value in connexion with the inquiry, which elements of the cerebral structure are nervous, and which belong really to the connective tissue? For my own part, I believe that any one who has studied the development of gliomata, of yellow softening, and of several other morbid changes, with unbiassed eyes, will rather incline to my opinion that all the granules in the brain are of the same nature, and are all equivalent to connective-tissue corpuscles.

1. Hyperæmia and Inflammation.

§ 688. We have already learned that each of the main divisions of the nervous system has its own special vascular arrangements; hence it cannot surprise us to find a considerable number of independent morbid appearances in the domain of hyperæmia, hæmorrhage, and inflammation. Dura mater, pia mater, cerebral substance and spinal marrow, peripheral nerves —have all got their special forms of hyperæmia and inflammation. Nay, the peculiarities are so striking, that we cannot adequately explain them by any mere difference in the distribution and number of the blood-vessels. The aggregate relations of the parenchyma to the vessels—their mutual influence—are not the same in the dura mater as in the pia mater, in the pia mater as in the brain. The customary arrangement, according to which each organ receives its special supply of arteries and veins, which then break up into capillaries in its interior, is really confined to the peripheral nerves. In the spinal cord, and still more in the brain, care seems to be taken that only the finest vessels, those which immediately subserve nutrition, and which are not subject to any variation in their calibre, should penetrate into the nervous matter. Accordingly the territories of nutrition in the brain and cord are everywhere very small; hence too, hyperæmic and inflammatory conditions of the central organs proper exhibit a twofold peculiarity; first, when due to local causes (*e.g.* wounds), they tend to limit themselves to small areas; and secondly, their extension over wider tracts is usually a consequence of intense *functional* irritation (Psychoses). On the other hand, in the pia mater, we have an enormous number of largish vessels, distributed through a parenchyma which hardly requires nourishment at all, but which possesses wide spaces, offering the most favourable conditions for the propagation of an inflammatory process and the accumulation of its products. This accounts for the tendency of congestions and inflammations in the pia mater to become diffused, a tendency resisted in acute cases only by the unyielding walls of the skull, while in chronic cases, and before the cranial bones are firmly consolidated, the field for their extension is practically unlimited (Hydrocephalus externus). The dura mater, owing to its extreme toughness, and the intimate way in which its bundles of connective tissue are interwoven, is incapable of satisfying whatever inflammatory tendencies it may possess, within its own parenchyma; hence both hyperæmia and exudation manifest themselves upon its inner surface, where they give rise to a very interesting series of textural changes, a series which we shall now proceed to consider in detail.

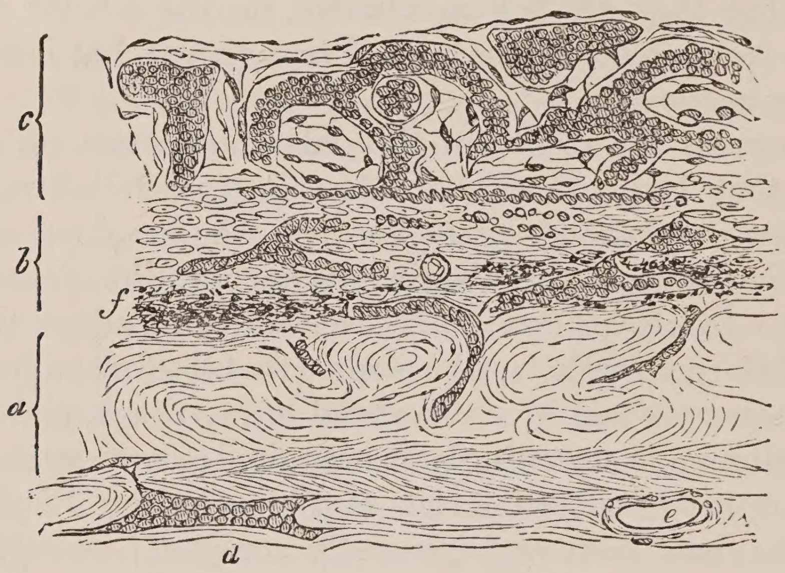
a. Pachymeningitis.

§ 689. Acute circumscribed suppuration of the dura mater, following penetrating wounds of the head, erysipelas, caries of the petrous bone, and occurring round softened thrombi of the venous sinuses, affords but slender materials for histological investigation. One point alone merits attention, viz. that the alterations are very prone to assume a gangrenous character, a tendency fully explained by the ease with which the few and narrow *vasa propria* of the membrane become plugged by coagula, and islets of parenchyma, of disproportionately large size, deprived of nourishment in consequence.

§ 690. The non-suppurative, internal, or hæmorrhagic pachymeningitis begins with a hyperæmia, which, according to *Kremiansky*, primarily involves, in by far the greater number of cases, the area of distribution of the middle meningeal artery —the bregmatic region—spreading gradually forwards, backwards and downwards from this point. The arteries are dilated, more tortuous than usual, and surrounded by a much thickened adventitia. The capillary hyperæmia manifests itself as a barely perceptible rosy flush of the internal surface of the membrane, usually so white and smooth; throughout the entire course of the disease, it remains stationary at this insignificant level. All the more remarkable are the changes which are developed on the surface of the dura mater in connexion with this hyperæmia. The naked eye observes, first of all, a lax, gauzy, yellowish efflorescence, studded with innumerable bloody points. This may readily be peeled off with the forceps, and if, while doing this, we fix our attention upon the line along which separation is taking place, we notice here and there, reddish threads stretched out between the dura mater and the false membrane, which are forthwith torn across. These threads are simply blood-vessels, passing from the dura mater into the false membrane, where they break up into stellate ramifications. If we examine the membrane microscopically, we are chiefly struck by the immense number of very wide and thin-walled vessels it contains. The walls of these vessels, which can hardly be called "capillary," exhibit a single, very fine contour; their calibre is, on an average, from three to four times wider than that of ordinary capillaries; moreover, they are irregularly dilated, bulging, and twisted now to one side, now to another (fig. 189, *c*). The substance in which these vessels run, and which is continuous throughout the whole of the false membrane, I am inclined to call mucous tissue. An accurate estimate of its true nature is, indeed, impracticable, owing to the variety of structures imbedded in it. I believe, however, that I have conclusively ascertained that its corpuscular elements are spindle-shaped and stellate, connected with one another by anastomosing threads of protoplasm; that they are few in number, on the whole; that the basis-substance is homogeneous and transparent, but is rendered cloudy by acetic acid.

As regards the origin of this false membrane, no one can demand that I should offer in this place a detailed refutation of the view propounded by *Lancereaux*, who has done so much for our knowledge of this disease; he assumes the occurrence of a *generatio cellularum æquivoca*. Neither can I adopt the older theory of German writers, who assume that the first rudiments of the formation are laid by a superficial hæmorrhage, and that the false membrane is accordingly an organised extravasation. I am inclined rather to adopt the view first broached by *Virchow*, and which has since been very generally accepted; he regards the false membrane as an efflorescence from the dura mater, and considers whatever hæmorrhages may occur in the course of the disease as due to the peculiar structure of the membrane itself. The most recent observations (those of *Kremiansky*) have taught us that the epithelium of the dura mater is slightly thickened at the edges of the false membrane, where it becomes continuous with its substance. *Kremiansky* thinks himself obliged by this discovery to assume that the epithelium has some share, however limited, in the production of the membrane. Supposing this view to be confirmed, it would still be restricted in its application to the very first beginnings of the process. Besides, the subepithelial layer of the dura mater is undoubtedly the chief source of the morbid products. The pores open and yield a passage, first to embryonic cells (possibly emigrant leucocytes?), and then to vessels; the former producing the lax connective tissue of the parenchyma, while the latter remain as the vessels of the newly formed membrane. The chief stress must therefore be laid on the development and dilatation of the vessels; for we may justly regard the newly-developed capillary network as a diverticulum or safety-valve for the increased tension in the substance of the dura mater, due to its being actively congested. The less the unyielding density of the fibrous tissue allows of a permanent increase in the calibre of the vessels and a deposit of young tissue round them, the greater will be the dilatation of the newly-formed vessels, which has only to contend against the general intra-cranial pressure.

FIG. 189.



Pachymeningitis chronica, hæmorrhagica. Vertical section through the dura mater and a stratified efflorescence on its surface. The dura mater, which contains an artery and a vein (*d*, *e*), the latter without any proper wall, lies below *a*. It is intimately united with the oldest layer of the false membrane (*a*). The latter resembles it in texture. (*b*). Layer of medium age, consisting of spindle-cell and round-cell tissue, separated from (*a*) by a streak of pigment (*f*). (*c*). Youngest, highly vascular efflorescence, separated from (*b*) by a thin layer of blood-corpuscles. $\frac{1}{300}$.

§ 691. Before speaking of the hæmorrhages which usually complicate the further course of the disease, I will bring the history of the false membrane itself to a conclusion. When we come across the mischief in a later stage, we find the membrane made up of several distinct layers (fig. 189). The innermost one (*c*) exhibits (supposing the process not to have been otherwise arrested) the characters of the "primary efflorescence" described in the foregoing paragraphs. It is the youngest, last-formed layer. The next one (*b*) differs from it by containing an incomparably larger proportion of corpuscular elements; its vessels, too, are somewhat narrower. The third (*a*) and all the succeeding layers are made up of a web of tough, lustrous fibres of connective tissue, whose texture is almost as dense as that of the dura mater itself, from which it cannot be distinguished by the naked eye. The whole process is obviously analogous to those modes of organisation with which we became acquainted when studying inflammatory proliferation in general. The morbid products consist of connective tissue in every stage of development. The only point of special interest in the present case is that cicatrisation constantly renews the groundwork adapted for the superficial efflorescence—that groundwork, which was originally furnished by the dura mater itself. This seems to me to explain the rarity of recovery from this condition, as well as the intermittent progress of the disease. No sooner has organisation resulted in a certain contraction of the vessels, than the tension of the blood in the inflamed membrane demands a new safety-valve; and this is forthwith provided by the efflorescence of a new membrane, furnished with capacious blood-vessels.

§ 692. We come now to the consideration of those intercurrent hæmorrhages, already alluded to more than once, which play so prominent a part in the clinical history of pachymeningitis. It is self-evident that the arrangement of the vessels in the false membrane must almost inevitably lead to their rupture. Even the thinnest efflorescences, therefore, are usually studded with bloody points, which may reach the size of a lentil. The thicker the false membrane becomes, the larger grow the hæmorrhages; until at last we find those pools of blood, as broad and thick as a man's hand, which used to be known as *Hæmatoma duræ matris*. All these extravasations, including the hæmatomata, are interstitial. The smaller bloody points are situated in the substance of the false membrane; the larger ones are invariably found between the youngest, telangiectatic layer of the false membrane on the one hand, and its older layers—or, when these are absent, the surface of the dura mater—on the other. The telangiectatic layer is stripped off by the effused blood, forming a sac which, in the larger hæmatomata, stretches over the clot like a fine cobweb. This used at one time to be considered as a peripheral, capsular coagulum of fibrin. Here and there, we may also find small quantities of blood in the sac of the arachnoid; this is due to leakage through the delicate membrane of connective tissue.

§ 693. Large hæmatomata speedily cause death by compression of the brain. A rare phenomenon is diffuse suppuration of the whole false membrane—a sort of inflammatory reaction against the extravasated blood, which thus becomes equivalent to a wound. I have seen an instance of this myself. On the other hand, we have frequent opportunities of observing the retrograde metamorphosis of the effused blood, and the development of numerous pigment-granules in the interior of the false membrane. Such appearances are most instructively presented by false membranes of old standing, whose growth has been arrested, and which are occasionally (though not very often) found in conjunction with more recent efflorescences, and are distinguished by their peculiar brick-red or bright rusty colour. In such membranes, the vessels are wholly obliterated; their course may, however, be distinctly traced by the pigment which has collected on both sides of them. The pigment is deposited in the form of red and reddish-yellow granules, aggregated in groups of from three to seven, in large, round cells. These pigment-cells are in contact with one another; it is only the interior of the vessel and the centre of each islet of parenchyma which are free from them, the general effect being very picturesque.

b. Leptomeningitis (*Meningitis, Arachnitis, Hydrocephalus*).

§ 694. Although the textures whose hyperæmic and inflammatory conditions we are now about to consider, form a continuous whole, yet their separate parts, the arachnoid, the pia mater proper, the choroid plexuses, and the ventricular ependyma, present so marked an anatomical individuality, that we cannot wonder at each of them playing a part of its own in the disorders by which they are collectively affected. To this we must add, that they are seldom or never all involved at once; at one time, it is the pia mater over the convexity of the hemispheres (*Meningitis of the convexity, Hydrocephalus externus*); at another, the pia mater over the base of the brain and in the Sylvian fissures

(*Basilar meningitis*); again, the disease may be restricted to the choroid plexuses and ventricular ependyma (*Ventricular meningitis, Hydrocephalus internus*); and since the localisation of each of these disorders corresponds roughly to the above-named natural divisions of the system, the peculiarities of the latter give rise to certain characteristic local modifications in the former, which distinguish the individual diseases from one another.

§ 695. Before going deeper into the subject, it seems advisable to devote a little space to some general remarks on the variations in the amount of blood contained in the brain and pia mater. We must first of all consider the influence exerted by the absolute limitation of the organ by the bony cranium. "For every quantity of fluid entering this space, a corresponding quantity of fluid must leave it; and *vice versâ.*" This would seem to entail a singular uniformity on the intracranial circulation. Since the pressure of the blood in the vessels would be directly transmitted to the parenchyma through the continuity of the surrounding fluid, the parenchyma, in its turn, being supported by the unyielding cranial bones, the contents of the skull (including the blood) would necessarily be everywhere exposed to the same degree of pressure, and the circulation would be kept up solely by the difference between the tension in the carotids and vertebrals before their entrance into the skull, and that in the internal jugular vein. The flow of blood through the interior of the skull would therefore be regulated by the same laws as the flow of blood through rigid tubes; any variation in the calibre of the vessels would be impossible; the elasticity of the vascular walls would be absolutely purposeless; an unusual proportion of the *vis a tergo* would be transformed into heat by friction; oscillations of tension, and especially any local rise of tension, a hyperæmia or a hæmorrhage, would be impossible, and so forth. Now all these consequences are actually realised, up to a certain point; we know that the walls of the intracranial arteries are abnormally thin in proportion to their calibre; (*e.g.* the calibre of the basilar artery is equal to that of the brachial, while its walls are barely one-third as thick); the great veins, the sinuses of the dura mater, really are rigid tubes. Notwithstanding all this, the consequences we have deduced are not *completely* realised; and this incompleteness can only be due to the fact that the cranial cavity is *not* absolutely closed; and this we find actually to be the case. The spinal marrow occupies rather more than one-half of the foramen magnum; the interval affords a free passage to the cerebro-spinal fluid. The latter can escape from the skull, when necessary for the turgescence of the cerebral vessels; it can make its way back in the contrary event; in short, it serves as a valve within tolerably wide limits; and within those limits, we must admit the possibility of variations in the intracranial pressure. Increase of pressure, owing to hyperæmia and exudation, can only occur within a limited area, and up to a certain point. The limits of compensation afforded by the valve once reached, no further rise of pressure can be caused by the afflux of more blood; it can only be caused by the irresistible growth of a solid tumour; and then it occurs at the expense of the cerebral blood-supply. The blood is driven out, or not admitted; with the final result of causing the patient's death. We shall often have occasion to recal these facts, in connexion with many diseases of the brain. As regards hyperæmia and inflammation of the pia mater and its appendages, they only afford, for the present, an explanation of that restriction to particular tracts, on which, as a characteristic feature, I laid some stress in the foregoing section.

§ 696. ACUTE HYPERÆMIA AND SUPPURATIVE INFLAMMATION of the pia mater over the convexity of the cerebral hemispheres will now engage our attention. This is the non-specific, often traumatic, rarely idiopathic form, popularly known as "inflammation of the brain." It consists of a tolerably well-marked congestion of all the vessels in the pia mater, together with purulent infiltration of the subarachnoid lymphatic spaces. The most striking point in connexion with it is the strict way in which the purulent exudation is limited to the parenchyma of the pia mater; it never transgresses the arachnoid lamella which forms its outer boundary. The comparison of the arachnoid to a serous sac, formerly so popular, met with a severe shock from *Luschka's* investigations* concerning the parietal lamella of the arachnoid; it seems now to have lost its remaining adherents, owing to this very striking deviation from the superficial character of serous inflammations in general. To me it seems as though this deviation were simply due to the presence of very distensible spaces immediately around the vessels. Here, if anywhere, we may apply *Cohnheim's* theory of inflammatory exudation (§ 89). Even the naked eye can show us that the pus everywhere originates along the course of the vessels. Like a double streak of a yellowish-white colour, narrow at first and growing steadily wider, the pus follows the edges of the vessels, especially of the large and small venous trunks which pour their contents into the longitudinal sinus towards the vertex. The longer the process lasts, the nearer do the purulent streaks accompanying the vessels approach one another, till they finally coalesce; the pia mater swells up as a whole; it often acquires a peculiar stiffness, owing to the stretching of its fibrous bands, perhaps also to the coagulation of some lymphatic constituents of the exudation; it may then be stripped from the compressed and bloodless, rarely softened, surface of the brain, together with the prolongations which it sends into the sulci—forming a solid mould of the cerebral irregularities.

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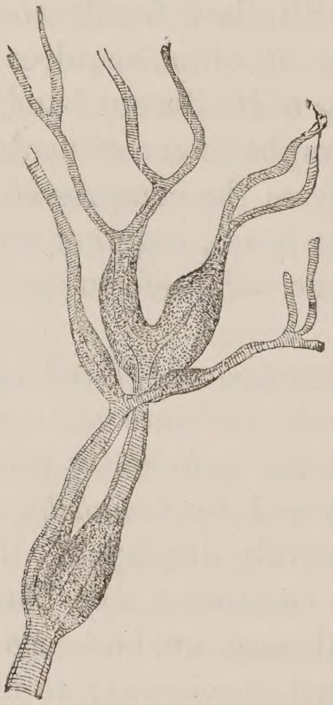
* *Luschka* proved that the so-called parietal layer of the arachnoid was merely the epithelium of the dura mater.

On putting a still transparent shred of the pia mater—one which happens to include a minute vein—under the microscope, we see, especially if it has previously been soaked in carmine, the appearances discovered by *Cohnheim* in the peritoneum of the frog, most instructively displayed. The plastering of the intima with colourless corpuscles, and the invariably moderate infiltration of the middle coat, are best seen in transverse sections made through hardened specimens; to us, however, the direct inspection of shreds of the membrane is of peculiar value, as it convinces us that every one of the pus-cells infiltrated into the pia mater has really emigrated from the vessels. Just outside the middle coat, the cells lie crowded together; the farther we recede from the vessel, the less numerous do the pus-cells become; until at length we find meshes of connective tissue containing only one or two corpuscles, or even none at all. These appearances can only be explained in one way. The pus-cells must be emigrant leucocytes.

§ 697. ACUTE BASILAR MENINGITIS (also called tubercular meningitis, because it is invariably associated with miliary tuberculosis) presents us with a sum-total of morbid appearances differing in many ways from that just described. The inflammation of the pia mater is not the central point of the disorder; instead of it, we may have multiple hæmorrhages into, and red softening of, the cortical substance; it is the fatal element in the disease; but yet it is a secondary one. The primary and essential phenomenon is the development of a number of tubercles in that part of the pia mater which lines the fissures and sulci at the base of the brain. These nodules are most abundant in the Sylvian fissure, where they originate in the sheaths of the arteries. This circumstance was fully considered in § 115, as a part of the general subject of Tuberculosis.

FIG. 190.

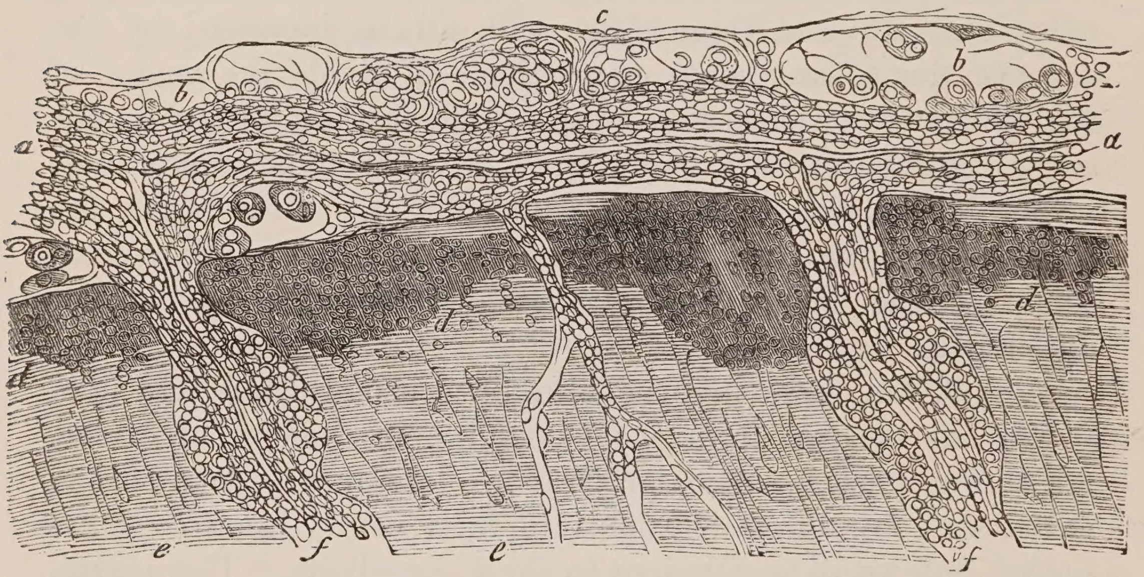


A twig of the Sylvian artery whose branches have undergone tuberculous degeneration. The miliary nodules developed in the adventitia, compress and narrow the vessel to some extent.

But little stress, however, was then laid upon the narrowing of the vessel by the miliary nodule (*see* fig. 190). The latter not only projects outwards as a round, or at any rate roundish tumour, but it pushes the middle and inner coats of the vessel before it, making them protrude into its interior. At a later period, both these membranes are actually perforated by the growth of the tubercle. On cutting open a tuberculous vessel in the direction of its length, and inspecting its interior, we notice that at the point where a perforating tubercle is situated, the usual longitudinal pleats of the intima, and the transverse striation due to the muscular fibres, are interrupted by a sharply circumscribed gap, through which the small cells of the tubercular tissue project. So that not only does the tuberculosis cause narrowing of the vessels, but it likewise impairs directly the firmness of their walls. We may conceive how this alone may give rise to the most severe local disturbances of the circulation. The rise in the blood-pressure behind the point of obstruction must cause extensive collateral fluxions; the destruction of the inner and middle coats must lead to extravasation; and these risks will all be increased by the supervention of any acute congestion. I divide the course of the inflammation into two stages: during the first and longer stage, the tubercles are being gradually developed, and a most favourable soil prepared for the inflammation; while during the second stage, the advent of an active congestion speedily occasions all the morbid appearances characteristic of basilar meningitis.

§ 698. On removing the brain, we usually find free fluid which has escaped from the ventricles, in the cranial cavity. All the ventricles, particularly the two lateral ones, take part in the disease by serous effusion into their cavity (*Hydrocephalus acutus*) and small sugillations in their ependyma. The depressions at the base of the brain are coated with a jelly-like exudation, which fills and distends the meshes of the pia mater; here and there, a yellowish clot may be found lying upon the free surface. The sero-fibrinous infiltration extends to the Sylvian fissure, where it assumes a purulent character "in patches," without ever developing the typical appearances of suppurative meningitis. The pus is only present in narrow, yellowish striæ, which accompany the vessels, and appear to the naked eye to blend with the far more striking tubercular proliferations. The latter, upon the Sylvian artery, are often a line in depth, cheesy and friable; while on its smaller branches they are still, as a rule, grey, translucent and less prominent. A special feature in tubercular meningitis is the implication of the cortex cerebri. This depends partly on an eruption of tubercles upon all those vessels which penetrate "naked" from the pia mater into the cortical substance, partly on a continuity between the inflammatory infiltration of the pia mater, and the surface which it clothes. The outermost, white layer of the grey cortex, which contains fewest corpuscular elements, is densely crowded in patches with immigrant (?) cells. On stripping off the pia mater, these infiltrated products stick to it, and the surface of the brain presents a rough, eroded aspect. Of greater moment in every case are the tubercular degenerations of the vasa propria of the brain. These extend to the very edge of the *centrum of Vieussens*, causing mechanical impairments and lesions of the cortical substance, not only by obstructing the vessels, but mainly by the numerous extravasations to which they give rise.

Fig. 191.



Vertical section through the pia mater and the adjacent part of the cortex cerebri in tubercular meningitis. *a a.* A largish vessel of the pia mater, whose sheath is entirely filled with inflammatory products; *b b.* Lymphatic spaces of the pia mater, showing the beginnings of a tubercular proliferation of the endothelia; *c.* Miliary tubercles in the pia mater; *d.* The outermost layer of the cortex cerebri, infiltrated with round-cells; *e.* Normal brain-substance; *f f.* Proper vessels of the brain-matter undergoing tubercular change.

I have a case on record, in which the cortical substance around the fissure of Sylvius was in a state of red softening; and this change could be readily traced to countless punctiform hæmorrhages from the tuberculous blood-vessels of the brain-tissue. *Rokitanski* also alludes to extravasations caused by the growth of tubercles.

§ 699. VENOUS CONGESTION AND ŒDEMA OF THE PIA MATER. HYDROCEPHALUS EXTERNUS. Protracted or often recurring irritative hyperæmia of the brain (Psychoses, Alcoholism) causes a permanent atony and dilatation of the veins of the pia mater; the resulting consequences coming all under the head of passive congestion and phlebectasy. That this is so, is clear from the close analogy of those appearances which follow mechanical hindrances to the return of blood from the cranial cavity, as in thrombosis of the sinuses of the dura mater, &c. Accordingly, the hyperæmia is situated in the region of the cerebral veins, along the longitudinal sinus. This sinus is either incapable of undergoing dilatation, or else its dilatation is prevented by the equable pressure of the soft, erectile edges of the cerebral hemispheres; at any rate, it shows no increase in its calibre. All the more marked is the distension of the six or eight pairs of large veins, which collect the blood from the entire surface of the hemispheres, and pour it into the longitudinal sinus. These are both elongated and dilated. Their elongation is manifested in an often extreme exaggeration of those spiral curves and angular flexures which their course presents even under normal circumstances. The smaller twigs, under the added influence of compression between the brain and the arachnoid, occasionally exhibit the most extraordinary loops, figures of eight, &c. The immediate result of this venous ectasy is an effusion of serous fluid, an œdema of the pia mater. The fluid is as clear as water, and contains but little albumen. It collects in the meshes of the pia mater; it may be freely and completely evacuated by puncturing the arachnoid at a dependent point. Its amount is often surprising, when we reflect that the space in which it is lodged ought by rights to be occupied by very different matters, and can only be provided by compressing and pushing aside the brain. Everything depends on the duration of the process; we are also acquainted with sudden effusions of serum into the meshes of the pia mater, with an acute œdema of that membrane, which may either subside rapidly, the fluid being reabsorbed by the veins, or else prove fatal by compression of the brain. The issue is different when the fluid collects slowly, when the brain has time to accommodate itself to the abnormal state. The degree of compression to which this so highly organised structure may submit, owing to its natural adaptability, is quite amazing. Not only are the convolutions gradually separated, and the sulci widened into trough-shaped depressions, but there also occurs a uniform diminution in the thickness of the hemispheres, between the surface of the ventricles and that of the cortex cerebri. The hemisphere shrinks to two-thirds, perhaps even to half its normal volume; and as the older authors found it hard to believe in the possibility of so extreme a degree of compression of the brain, they found a way out of the difficulty by assuming a *Hydrocephalus ex vacuo*—*i.e.* they regarded the atrophy of the brain as primary, the effusion as secondary—as destined to fill the vacancy left by the recession of the cerebral substance.

There is only one point of histological interest, and that not a very important one, connected with *Hydrocephalus externus*—I allude to the so-called "milky opacity" of the pia mater in the immediate neighbourhood of the vessels. This milky opacity has been justly viewed as an induration of the connective tissue. It begins as an infiltration of the tissue with colourless corpuscles, and so presents some analogy to purulent arachnitis. The degree of the opacity depends, in its later stages also, on the number of the infiltrated round-cells, though in addition to this change, there occurs a fibroid transformation—a growth of new connective tissue. The external layer of the pia mater, including the arachnoid, is ultimately converted into a rather tough membrane, from whose under surface the vessels which penetrate into the cerebral tissues arise; these traverse the interval between the membrane and the surface of the brain—an interval which is often very considerable—either naked, or surrounded by a small quantity of connective tissue. The brain-substance itself is tough and leathery, dry, in parts sodden; *i.e.* softened, without the production of pus or any other morphological elements.

§ 700. HYDROCEPHALUS INTERNUS. In speaking of tubercular meningitis of the base, a passing allusion was made to the implication of the cerebral ventricles in that disease. A moderate dilatation of the lateral ventricles is a nearly constant phenomenon of its morbid anatomy; it is due to an acute effusion of clear, straw-coloured serum into their interior (*Hydrocephalus acutus*). The cause of this effusion must be sought in the continuity of the pia mater at the base of the brain with the choroid plexuses. In many of these cases I have found the twigs of the choroid arteries studded with miliary nodules. The tubercles are quite as competent to cause disturbances of the circulation, hæmorrhages, and serous effusions here, as in the remaining branches of the internal carotid, particularly the Sylvian arteries (§ 697): we have only to understand how the isolation of the pia mater from the brain in the present instance determines the effusion of fluid, not into the parenchyma, but upon the free surface of the choroid plexuses, *i.e.* into the cavity of the ventricles.

§ 701. The pathology of chronic hydrocephalus is beset with far greater difficulties. A progressive accumulation of watery fluid in the ventricles of the brain (and of the spinal cord, as we must add, in order to include the analogous conditions of Hydrorachis, Spina bifida, &c.) leads to a proportionate dilatation of those cavities and to a centrifugal thinning of the cerebral hemispheres, as well as those other parts of the brain which immediately enclose the ventricles. The distension of the nerve-centres is propagated to their bony capsule; so far at least, and so long as the sutures have not been obliterated by osseous union. In the latter case (acquired hydrocephalus), the brain-substance is subjected to a higher degree of centrifugal pressure, but it is not thinned to the same extent as in congenital hydrocephalus. Again, we have to distinguish between two forms of the congenital disorder; in the first, the effusion occurs during the earliest period of fœtal life; it ruptures the cerebral vesicles, and arrests the development both of the brain and of the skull (anencephalous fœtus, hemicephalous abortion): in the second, the fluid is only poured out towards the close of gestation; this gives the child its best chance of life (supposing parturition to have occurred without accident), since the ununited sutures between the cranial bones yield to the distension of the brain without any extreme or hurtful degree of opposition; while on the other hand, the singular capacity of the brain for adapting itself to abnormal conditions, enables the psychical functions to go on.

The domain of hydrocephalus also includes those circumscribed and partial bulgings of the ventricular cavities and of the central canal of the spinal cord, which are known as hydrorachis, spina bifida, encephalocele, myelocele, encephalo-myelocele.

§ 702. If we inquire into the cause of such effusions, into the essential nature of hydrocephalus, we must own regretfully that we are still far from having a theory which embraces and explains all the phenomena. *Virchow* is disposed, basing his view on the behaviour of the ventricular ependyma, to assign an inflammatory origin to the process; its analogies with acute hydrocephalus might fairly be appealed to on the same side. For my own part, I am also disposed to appeal to acute hydrocephalus, but only in order to obtain a basis for further investigation. We have seen that in acute hydrocephalus the effusion is due to interference with the circulation in the choroid plexuses. Whatever be the cause of this interference, it suffices to explain the occurrence of effusion; it is our duty, therefore, to examine the choroid plexuses in chronic hydrocephalus also, in the hope of discovering in them the source and seat of the disease. Now we find that the plexuses are invariably congested; on placing shreds of them under the microscope, we see that their surface is clothed with countless small, unbranched, but very vascular papillæ. Each of these papillæ consists of a thick layer of epithelial cells, investing a central stem almost entirely made up of blood-vessels. The epithelium presents in all its layers (from two to three in number) the well-known forms described by *Henle;* roundly-polygonal elements, with thorny processes extending into the interstices between adjacent cells, and penetrating as far as the connective tissue of the papillæ. It would be more correct to say, as far as the vessels of the papillæ—for their membrana propria seems really to be the only connective tissue present; I have never seen more perfect examples of epithelium-bearing vessels. We shall learn hereafter that the production of epithelium-bearing vessels is a local peculiarity—not of the choroid plexuses alone—but of the "cerebral surface of the pia mater" generally, of which the surface of the plexuses is only a part. Very interesting tumours, which will be considered among the myxomata and psammomata, owe their existence to it; and the history of cerebral cancer will show us that the heterologous production of epithelial cells is also connected with it, and is therefore less heterologous than it might seem to be at the first glance.

To resume: the presence of such papillæ in certain parts of the choroid plexuses is so constant, even in healthy persons, that we cannot attribute any importance to it, save where the number of the papillæ is unusually great; and even then, their connexion with the abnormal amount of the cerebro-spinal fluid seems a very remote one. I would lay far more stress on any hyperæmia, however trifling, whether active or passive, of the plexuses; calling the reader's attention to the fact, that it is just these hyperæmiæ and exudations, which, on account of their immediate relation to the cerebro-spinal fluid—the safety-valve of intra-cranial pressure—might be expected to carry the day more readily than those in other regions of the cranial cavity.

The importance of the alterations in the ventricular ependyma has, in my opinion, been much overrated. The ependyma grows thicker and more dense; in certain regions, moreover, *e.g.* upon the optic thalami, the fornix and the stria cornea, we find partial thickenings in the form of small translucent nodules, projecting from the surface like dewdrops. Neither the general nor the partial thickenings, however, are in any way connected with the vessels; the ependyma—by which I mean the limitary layer of the neuroglia, apart from its epithelial coat—allows the vessels of the subjacent parts of the brain, with their main branches, to shine through it; but it never contains any vessels of its own, and must therefore be regarded as a septum of perpetually increasing thickness between the free surface and the cerebral vessels. When the ependyma is much thickened, it contains exquisite networks of stellate corpuscles; the individual elements are often furnished with double nuclei, elongated and branching, chiefly in the direction of their long axes; the intercellular substance is finely fibrous, and stratified in such a way that the fibres of the deeper layers appear in transverse sections to meet those of the more superficial ones at an acute angle. The beaded thickenings, which are also met with in the fourth ventricle apart from hydrocephalus, and associated with a great variety of clinical symptoms (epilepsy, masticatory spasm, impairment of speech, &c.), are also entirely made up of fibrous tissue with very few corpuscular elements.

§ 703. In connexion with internal hydrocephalus, some allusion must be made to what is known as WHITE SOFTENING; for it is still uncertain whether this change be wholly due to "post-mortem maceration" of the brain-substance in the hydrocephalic fluid, or not. The phenomenon itself would be the same in any case; but the punctiform hæmorrhages which are occasionally present can hardly be explained without some *vis a tergo*—*i.e.* without circulation and life. The changes consist in a softening and disintegration, first of the neuroglia, then of the nerve-fibres. Thus there originate, at various points of the ventricular surface, and especially in the posterior horn, shallow clefts in the white matter, extending to a depth of from one to two lines into the wall of the ventricle. No morphological elements, such as pus-cells, &c., are developed.

c. *Hæmorrhage.*

§ 704. Before going on to consider the hyperæmic and inflammatory states of the brain-substance itself, we shall pause for a moment midway between the pia mater and the brain—*i.e.* we shall discuss some alterations in the cerebral vessels, and the various forms of cerebral hæmorrhage; for these are variously and intimately connected with the inflammatory states we have just been studying, while a knowledge of them is an indispensable preliminary to the study of cerebral inflammation proper.

Apart from traumatic extravasations into the so-called "arachnoid sac," owing to the veins of the pia mater being torn from the longitudinal sinus; apart from the rare cases in which an aneurism has burst at the base of the brain, intracranial hæmorrhage is always due to rupture of the proper vessels of the brain, *i.e.* of those which run in the cerebral substance itself.

Morbid anatomists usually draw a broad line of distinction between massive and punctiform hæmorrhages, according to the quantity of blood poured out. This distinction is also an etiological one, inasmuch as massive hæmorrhages are invariably preceded by disease of the vessels, while the punctiform extravasations are due to a greater variety of causes. Small bleedings occur in all cases of acute inflammation of the brain; we are familiar with hæmorrhage as a complication of hyperæmic and inflammatory disorders of other organs, such as the serous and mucous membranes, &c.; but nowhere are sugillations so constant an accessory as they are here. Again, the plugging of a small cerebral artery by an embolus, after causing congestion and stasis within the area of its distribution, gives rise to punctiform hæmorrhage. Thirdly, endoarteritis (§ 215) affects the medium-sized and smallest arteries, as well as the greater trunks at the base of the brain. The vast majority of massive hæmorrhages are due to a previous fatty erosion of those medium-sized twigs of the Sylvian artery, which penetrate through the *locus perforatus anticus* into the corpora striata. But endoarteritis may also cause punctiform extravasations, though in a somewhat different way. The bleeding occurs from the arterioles, which are markedly dilated, so as actually to constitute fusiform aneurisms. Of course I am not alluding to those dissecting aneurisms, which are themselves a not uncommon variety of punctiform hæmorrhage (*see* Psychoses), but to a uniform dilatation of the wall of the vessel, analogous to the true aneurism of the larger arteries. The vessels are converted into wide, inelastic, thin-walled tubes; of the structural elements of their wall and their triplicate arrangement, hardly a trace remains. Instead of the inner and middle coats, we see a limited number of flat nuclei; their nucleoli are often double, and their edges notched and constricted; hence we may infer that proliferation is going on. The endothelium, with the inner and middle coats, have accordingly succumbed to a proliferative change; their destruction, particularly that of the middle coat, entails the loss of that constituent of the vascular wall which mainly enables it to pass from dilatation to contraction, and so to withstand the pressure of the blood. The wall of the vessel, stretched beyond all measure, gives way here and there, and allows the blood to escape. Fourthly and lastly, the *Morbus maculosus Werlhofii* (Purpura hæmorrhagica) manifests itself in the brain by a number of punctiform ecchymoses. To sum up, then, we find that massive hæmorrhage is a result of atheromatous degeneration; while the punctiform variety may either be due to this, or to simple inflammatory congestion, or to embolism, or to purpura.

§ 705. The textural changes associated with cerebral hæmorrhage may be studied far better in the punctiform than in the massive variety. Accordingly, we will confine our attention, for the present, to the former. In punctiform hæmorrhage, only a minute quantity of blood appears on the outside of the vessel, where it collects in the form of a spherical drop. The bleeding is kept within these narrow limits by the rapidity with which the resistance of the surrounding nerve-tissue, augmented by the extravasation, becomes equal to the intravascular tension. This explanation is even better suited to those punctiform hæmorrhages, peculiar to the psychoses, in which the blood does not get actually outside the vessel, but, restrained by the detached and bulging adventitia, forms what is known as a dissecting aneurism (*see* § 714). There can be no doubt that here the arrest of the bleeding is mainly due to the reaction of the extravasated blood, aided by the tension of the adventitia. But in the free variety of hæmorrhage also, the minute orifice in the wall of the vessel, caused by a momentary separation of its tissues, is immediately closed. This is the form of hæmorrhage known to the older writers as "diapedesis."

Punctiform extravasations are invariably multiple; their naked-eye appearance is partly denoted by their name, partly modified by the special cause to which they happen to be due. In purpura and the diffuse inflammations of the cortical substance (Psychoses), we find the bloody points uniformly distributed throughout the brain-substance or cortex cerebri; in all other cases, the morbid appearances are limited to isolated patches; we can distinguish between a central region which is most severely affected, and a peripheral zone in which the morbid appearances decrease in intensity from within outwards. It is a singular fact, moreover, that the first of the morbid appearances, those which immediately follow the hæmorrhage, are the same, whether we have to do with a circumscribed inflammation, with an embolism, or with degenerative changes in the vessels. We find the brain-matter studded with bloody points over an area of from a quarter to one square inch or more; their size is very uniform, but they increase in number towards the centre of the affected part, where they are very closely crowded. The brain-substance, partly displaced, partly compressed, exhibits a slight reddish discoloration round each of the bloody points; where these are crowded, the reddish areolæ coalesce, so that the affected part, on a cursory examination, presents the appearance of a reddish-yellow patch, dotted with a large number of bright red points.

§ 706. Passing on to consider the further destiny of the extravasated blood, we come, in the first place, to distinct proof of its coagulation. In the interior of each drop of blood, we find the well-known network of coagulated fibrin, in whose meshes the blood-corpuscles lie; moreover, we notice a membrane which invests each globule, and forms a capsule round it. This membrane is of variable, though never of any great thickness, and consists of a soft, originally homogeneous and translucent substance. It is quite plain that these appearances are due to a secondary precipitation of some albuminous substance at the periphery of the extravasation, having nothing whatever to do with the coagulation of the fibrin; but if so, we must find some explanation of its real nature. Now I think that a simple application of the results arrived at by *Alex. Schmidt*, with reference to the development and precipitation of fibrin—results which I have embodied in § 186—will satisfy all our requirements. The encapsulation of the effused blood would thus be due to a precipitation of fibrin—the fibrinogen being supplied by the nutrient fluid which bathes the clot, while the fibrino-plastic matter is derived from the blood-corpuscles. This fibrinous capsule is always present; I insist upon its real nature, because I believe it has often been misinterpreted. If we confine ourselves to the examination of sections from a patch of punctiform apoplexy which has been previously hardened, we may readily mistake the capsule for the wall of a vessel distended with blood and cut across transversely; we should thus extend unduly the domain of interparietal hæmorrhage. We ought therefore to assure ourselves, by the examination of shreds teazed out and treated with glycerine, that the bloody points are really susceptible of being isolated in the form of spheroidal globules, each of which is enclosed in a proper capsule. On pressing down the covering-glass gently, the capsule may be ruptured, and the blood-corpuscles contained in it squeezed out. We then have the empty shell remaining, in whose interior we can now recognise the fibrillar reticulum of the original fibrin.

§ 707. Up to this point, all cases of punctiform hæmorrhage run the same course. From this point, however, they diverge, and the apoplectic part advances towards one of three issues: yellow softening, suppuration, or direct organisation. This diversity is partly due to the cause of the lesion, partly to the behaviour of the brain-matter. Of the new morbid appearances which come before us, one only, *sc.* cicatrisation, is exclusively a result of apoplexy; the remaining ones stand on a broader basis, for they may be caused in other ways as well; they will accordingly be described, either under inflammation of the brain (red softening and suppuration), or independently (yellow softening). Here, therefore, we may confine ourselves to the "direct organisation" of the apoplectic focus. This is naturally divided in the case of each individual extravasation, into the organisation of the capsule and that of its contents.

To take the latter first: I used at one time to teach that colourless corpuscles gradually took the place of the red ones. This change occurs without any rupture of the capsule; it seems as if the red corpuscles were directly transmuted into white ones. I still maintain this view, which I have confirmed experimentally; though I quite admit that owing to the migratory powers of amœboid cells, which have been discovered in the meantime, the idea that they may have entered the capsule from without has acquired probability and deserves further consideration. When once the red corpuscles have all been replaced by leucocytes, there is nothing to hinder the direct conversion of this embryonic tissue into fibrous connective tissue; this accordingly ensues, the fibres being arranged in concentric laminæ.

In the meantime, the capsule has also become organised; interstices are seen, running parallel with its surface, which divide the capsule into several strata or lamellæ; connective-tissue corpuscles (probably immigrant leucocytes) make their appearance in these interstices; finally the connective tissue of the capsule blends with that in its interior to form a tough nodule of relatively small size.

The course of these changes is modified only where the bloody points are so closely crowded that the adjoining capsules touch one another. Under such circumstances, I have observed an intimate coalescence and fusion of the capsules, the final result of which is a sort of cavernous tissue whose meshes are filled with clear serum. Now as these meshes formerly contained the extravasated blood, we may fairly inquire what has become of it. On this point I have no valid opinion to offer.

§ 708. So much for the metamorphoses which punctiform extravasations undergo. Let us now endeavour to apply the knowledge we have just gained to the explanation of the phenomena presented by massive hæmorrhages. Suppose that one of those larger branches of the Sylvian artery which penetrate into the corpus striatum from below has given way; the blood has rushed through the opening in a mighty flood, and has torn up the brain-matter in every direction. It has forced its way outwards into the centrum of *Vieussens.* It has displaced the optic thalamus inwards; it has first elevated the corpus striatum and then perforated it at several points, escaping into the lateral ventricle. The region of the lenticular nucleus is occupied by a pool of blood, two inches long and half an inch in breadth and depth. The demand for space which such a condition necessarily involves, is satisfied partly by the total expulsion of the cerebro-spinal fluid, partly by the blood being squeezed out of the cerebral vessels; when we strip the dura mater from the surface of the brain after death, the sulci are seen to be effaced, the gyri flattened, and all the veins about the vertex so completely emptied, that their finer branches are no longer visible to the naked eye. We may well ask whether death is not inevitable in cases of hæmorrhage so extensive. But I would remind the reader, that it is just in cases of massive bleeding into the brain that the possibility of repair (as regards the individual lesion) lies within very wide limits. The first shock once tided over, the mere coagulation of the effused blood brings some relief to the compressed brain; the clot contracts powerfully in all its dimensions; and although the functional troubles due to the rupture of so many important communications between the central and peripheral organs of the nervous system persist for a long time, the blood is nevertheless readmitted into the vessels comparatively soon, and the risk of death from lack of nourishment for the brain is thereby warded off. The repair of the lesion sets in without delay. Here too, the first step is the formation of a fibrinous capsule round the entire periphery of the clot; this capsule indeed, is thicker in proportion to the greater quantity of fibrinogen and fibrinoplastic matter which is at hand. All writers are agreed in affirming the existence of this capsule. It is originally a line or more in thickness; soft as jelly, and of a translucent yellowish tint. At a later period, it undergoes a metamorphosis analogous to that of the capsules in the punctiform variety of hæmorrhage; it becomes converted into a far thinner, but on the other hand far stronger layer of fibrillar connective tissue, which permanently shuts off the apoplectic deposit from the surrounding brain-tissue. We know comparatively little about the changes which the effused blood undergoes. The hæmatin is dissolved, and often soaks the tissue round the clot to a considerable distance, until at last it is taken up and removed by the vessels. A portion of it is converted into pigment, which remains in the cicatrix in the form of yellow granules and crystals of hæmatoidin. The rest of the blood is converted into connective tissue; though its quantity, as in arterial thrombi, is most insignificant. Scanty as it is, however, it suffices to glue the opposite walls of the capsule together, and so to convert the entire deposit into a simple strip of connective tissue—a cicatrix in the usual sense of the word. This result, however, is very rarely accomplished. More commonly we find, not a strip of connective tissue, but what is known as an "apoplectic cyst"; *i.e.* the walls of the secondary capsule do not collapse, the interval between them being filled with a clear, straw-yellow or colourless fluid, in which the connective tissue resulting from the organisation of the clot itself is suspended like a thin, gauzy veil. To explain this modification, we must recollect the necessity which exists, that the huge gap in the cerebral tissues should be replenished; accordingly, these cysts are only met with in the interior of the hemispheres, where the gap cannot be otherwise filled up; while the rarer apoplectic deposits on the surface of the brain form simple cicatrices, the resulting depression being taken up by a small quantity of meningeal serum.

As regards the changes undergone by the brain-matter in the immediate vicinity of the clot, I need only say that the portion actually torn or broken up is liquefied by fatty metamorphosis and then removed; to this point we shall return under the head of yellow softening. It would be interesting to know something more about the mode of sequestration—the isolation of the whole from the injured parts; at present, however, we have no information on the subject.

d. Encephalitis.—Myelitis.

§ 709. I have touched elsewhere on the grounds which may in some measure explain the singular fact, that all inflammations of the cerebrospinal substance, except those due to functional irritation, tend to limit themselves to the smallest possible areas (§ 688). I must now reassert the fact, calling the reader's attention to the marked contrast as regards extent, acuity and symptoms, which exists between what is popularly known as "inflammation of the brain" (Meningitis), and true inflammation of the brain-substance. The latter is always due to a wound or injury in the widest sense of the term, *i.e.* to some local irritation of extra-cerebral origin. The skull may have been struck or shaken; it may have been penetrated by a cut or stab which has directly damaged the brain, or a focus of inflammation and suppuration, originating in the neighbourhood of the brain, may have been propagated to its tissues at the point of contact; or finally, the plugging of a vessel, atheromatous disease, &c., may have caused a circumscribed punctiform hæmorrhage, followed by inflammation as a secondary consequence.

§ 710. In encephalitis and myelitis, the behaviour of the proper parenchyma of the brain and cord is the main point to be attended to; this is usually said to undergo purulent liquefaction; and the assertion is so far true, that a deposit of pus is ultimately found in the place of the cerebral substance. But the statement throws no light on the way in which liquefaction occurs. And no exhaustive theory can be expected in the present anarchical state of our doctrines concerning suppuration. We can but express suppositions, keeping a firm hold on individual facts of unquestioned certainty to serve as guides. Among these I include the passive behaviour of the nervous elements in the suppurative process, and the intense activity of the vascular system in every stage of the disease. The nerve-fibres within the affected area, are partly suspended in the pus as disconnected fragments, partly protruded from the walls of the cavity in a state of advancing maceration and decay. I have not been able to detect any traces either of fatty or of granular degeneration in them; drops of myelin separate from their surface; the axis-cylinders grow thinner by degrees and finally disappear. The ganglion-cells of the affected part become darkly-granular and break up into splinters; I have often recognised well-marked fragments of them in the pulp. The behaviour of the ganglion-cells in the immediate neighbourhood of the focus will be alluded to later.

The coarser appearances of the disorder, and perhaps also its finer details, are in great measure accounted for by the peculiar way in which the vascular apparatus is involved. The intense hyperæmia which ushers in the morbid changes invariably gives rise to a large number of minute ecchymoses; these, of course, are equally numerous when the hæmorrhage is the primary and the inflammation the secondary phenomenon. Should the affected part undergo softening and purulent liquefaction, the extravasated blood mingles with the pulp, giving it a more or less intense red colour. Hence the name RED SOFTENING, so generally applied to parts affected by encephalitis and myelitis, but which, of course, is equally applicable to other cases, in which similar effects are produced by very different causes. The presence of pus is characteristic of the inflammatory form of red softening; so too the presence of an areola, from one to two lines in width, round the focus of softening, in which the parenchyma is studded with numerous bloody points, and swollen by a commencing purulent infiltration.

The most important of all the questions which arise during the study of encephalitis, is that concerning the source of the pus. And this has not yet been satisfactorily answered. *Meynert*, on the strength of his microscopical researches, assumes a suppuration of the ganglion-cells by division and endogenous proliferation of their nuclei. My own investigations have taught me that the pus first collects round those vessels from which extravasation has occurred. In transverse sections of encephalitic foci (red softening), hardened in preservative fluids, we find these vessels girdled by a relatively wide areola of pus-cells; and by dint of careful management, we may even pull vessels coated with pus—furnished with regular sheaths of pus-corpuscles—out of the recent specimen. Finally, we may also see in transverse sections that the pus has actually pushed the extravasated, but still fluid, blood away from the vessels, the blood-corpuscles forming a ring round the pus, instead of a globular drop. This would lead us to infer that the pus was generated by the adventitia, or furnished by the emigration of leucocytes. Nevertheless I am loth to refuse the power of generating pus to the neuroglia; I am quite sure that it is capable of producing corpuscular elements (solitary tubercles, gliomata); and though I regard the results of my inquiries, just given, as trustworthy so far as they go, yet I do not consider them exhaustive.

Outside the actual deposit of pus, we find (though not invariably), a zone of œdema, in which, according to *Meynert's* investigations, the nervous as well as the non-nervous elements undergo a series of changes, whose interest is enhanced by the fact that *Meynert* seems disposed to attribute to them a considerable share in "chronic inflammations of the brain," as he justly terms the psychoses. In these ganglion-cells, *Meynert* describes a vesicular deformation of the nuclei, a nuclear fission either simple or repeated, a dropsical enlargement and a sclerosis, and finally a molecular disintegration and obsolescence of the body of the cell. Of these metamorphoses, the dropsical enlargement of the nuclei and cells may be regarded as peculiar to red softening; the sclerosis has already been described by *Rokitanski* under the name of "colloid transformation." The protoplasm is much increased and assumes a homogeneous, highly-refractive quality; the entire cell looks fuller, and its processes become swollen and clubbed. The nucleus disappears; the nucleolus may even precede it. *Meynert* tries to explain this condition as an infiltration (of the cell) with protagon, the main constituent of the nerve-medulla, discovered by *Liebreich*. These changes, with the exception of the nuclear fission in the ganglion-cells (which I have never been able to demonstrate with satisfaction to myself), are all of a retrograde character; we might add the calcification and excessive pigmentation described by *Förster*, the former of which is also met with round old patches of encephalitis; here too, however, we may assure ourselves that the part taken in the disorder by the nervous elements is an entirely passive one.

§ 711. We have no positive data concerning either the possibility or the *modus operandi* of repair after recent encephalitis. Still, I think it likely that certain forms of yellow softening, as well as of the so-called "apoplectic cysts," may prove to be the final results of encephalitis. In that case, the yellow softening would represent an arrest of the process, the apoplectic cyst a cicatrisation; both would, however, be "modes of repair" as contrasted with the far more usual issue of the inflammatory changes in ABSCESS OF THE BRAIN. In the foregoing paragraphs, something has been already said about the way in which this issue is brought about; and it was with especial reference to cerebral abscess that I left the question concerning the participation of the neuroglia open. The essential feature in the production of what is known as an "abscess" of the brain is a tough capsule of connective tissue, which shuts off the pus on every side from the brain-substance. This capsule, which may even be half-a-line in thickness, passes so continuously into the surrounding nervous tissue, that the idea of an independent production of connective tissue from the nervous matter suggests itself spontaneously. We must leave this interesting problem to be solved by experimental researches, such as have been already prosecuted in this field (*Leidesdorf* and *Stricker*), but which have not yet touched the root of the matter, *sc.* the source of the inflammatory corpuscles. For my part, I can offer an accurate description of the appearances presented by an abscess of old standing; transverse sections including the capsule and the nervous parenchyma in contact with its outer surface, and extending well into the healthy tissues, were examined. I shall take the appearances in their order from within outwards. The pus is of a greenish-yellow hue, synovia-like in consistency, usually acid, inodorous and very bland, without any tendency to decomposition. The pus-cells are, for the most part, multinuclear; possibly owing to their prolonged maceration in a feebly acid medium. The surface of the lining membrane is smooth. It derives a yellowish-white, opaque aspect from a continuous, tolerably thick layer of cells undergoing fatty degeneration. Next to these is a layer of regular embryonic tissue, which makes the surface uneven and wavy, owing to its thickness not being uniform. The embryonic tissue is continuous externally with a very loose spindle-cell tissue, which is distinctly stratified in a direction parallel to the surface, and only allows a fibrous band to penetrate obliquely into the summits of the hillocks of embryonic tissue here and there. This layer consists throughout of the most perfect spindle-cells; each apparently simple fibre may be recognised as a fibre-cell on more careful inspection, so that it would really seem as if, in this instance, all the connective-tissue fibres in the next layer had originated from spindle-cells. Of the proper fibrous layer of the capsule, on which the varying thickness of the whole membrane depends, there is little to be said. Besides the fibres, it contains a large number of cells, some round, some caudate. These increase in number towards its outer surface, where they are actually in excess of the fibrous elements and for the most part assume the character of fatty granule-cells, thus forming a second zone of fatty degeneration which separates the walls of the abscess from the nerve-tissue. I assume that the pressure of the growing abscess, while causing a certain reaction on the part of the surrounding tissues in its capacity as an inflammatory irritant—a reaction manifested by the proliferation of large numbers of young cells—also hinders the due filling of the vessels, which it can easily do under the peculiar conditions governing the intracranial circulation. Fatty degeneration of the newly-formed cells is the result; a zone of yellow softening between the capsule of the abscess and the brain. The softening, however, never amounts to a complete solution of the parts; we can readily assure ourselves that the softened tract is permeated by a network of coarse fibres, which unite with the capsule on the one hand, with the nerve-tissue on the other. These fibrous bands are bundles of primitive nerve-tubes, enclosing a few ganglion-cells when the lesion is situated in the grey matter; they are compressed, and run parallel to the surface of the abscess, a position which they can only have adopted under the pressure of the abscess itself. It is only when the capsular membrane is stripped from the brain-matter, that they are stretched out in the form of a network. The soaking they have undergone in the pulp has isolated the individual fibrillæ most beautifully; the ganglion-cells are squeezed flat, and here and there converted into long spindle-shaped or ribbon-like forms; their axis-cylinder processes are mostly intact; the only sign of atrophy I could detect, was a gradual loss of bulk (obsolescence, *Meynert*), not a fatty, colloid, or other specific metamorphosis. The neuroglia, in its old form, has wholly disappeared; it has been converted into the young cells and their equivalent—the fluid products of softening. On attempting to trace the beginnings of the lesion farther into the surrounding nerve-tissue, our search will, for the most part, prove fruitless; it is only here and there that I have been lucky enough to observe the first division of the neuroglia-nuclei; I do not scruple, however, on the strength of these, and of analogous observations on other morbid processes, to conclude, at least provisionally, that the stratum of connective tissue which isolates the abscess, together with the intermediate layer of cells which are undergoing fatty degeneration, is entirely derived from the neuroglia.

The phenomena of acute myelitis leading to abscess, are exactly similar to those of encephalitis. The form of the affected part varies with the injury. Fractures of the spine usually crush the cord; inflammation and suppuration taking place round the crushed part and isolating it from the healthy tissue.

e. Hyperæmia and Inflammation in Psychical disorders.

§ 712. *Meynert's** striking researches into the pathological histology of the psychoses, vindicate a prominent place for the nervous elements of the cortical substance in the morbid anatomy of these disorders. *Meynert* attempts to prove that the various kinds of excitement correspond to demonstrable changes in definite groups of ganglion-cells. We can only wish that more and more reliable data should be collected in this direction.†

There are no *a priori* grounds for opposing the physiological claims of the nerve-tissue to be the primary seat of the psychoses. Unfortunately, however, what evidence morbid anatomy may have accumulated on this subject, points still to abnormalities in the distribution of the blood, with their consequences, as the essential anatomical groundwork of all psychical disorders. It is only because the various authors who have turned their attention to this subject have each bestowed an exclusive attention on some one feature of the structural alterations, that the mutual connexion and interdependence of the various phenomena have never been placed in a sufficiently clear light.

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* Dr. *Theodor Meynert:* Der Bau der Grosshirnrinde und seine örtlichen Verschiedenheiten, nebst einem pathologisch-anatomischen Corollarium. Vierteljahrschrift der Psychiatrie, 1867. Heft. i. p. 77.

† *Meynert* bases his views on a certain number of highly valuable facts concerning the structure of the grey matter of the cerebrum. He shows that that inflected edge of the cortex cerebri, which, invested on both sides by medullary substance, forms the uncinate convolution (*subiculum cornu Ammonis*) and the hippocampus major, contains only multiple pyramidal —so-called motor—ganglion-cells; that the olfactory lobe (much less developed in man than in many mammals) contains only smaller, rounded —so-called sensory—ganglion-cells; that the claustrum, amygdaloid nucleus, and wall of the Sylvian fissure, are chiefly provided with fusiform nerve-cells connected with the fibræ arcuatæ of *Arnold*, &c. He refers these local differences, whose existence no one can dispute, to differences in function, and goes on to anticipate that their recognition will shed an important light

§ 713. Accordingly, we must concentrate our attention almost entirely on a chronic hyperæmia of the cortical substance, as the common foundation of all further mischief. In most cases, and at a certain stage in all, we may regard this hyperæmia as functional, as identical with that active congestion of the glands and membranes which coincides with every exaltation of their activity. Every functional hyperæmia is characterised by its localisation in the capillaries—the vessels which are most immediately in contact with the active elements of the organ—and by its periodicity. The latter feature reflects the functional exhaustion of all organs, their diminished excitability, their need of repose and restoration. Suppose, however, that some violent or artificial stimulus prevent the apparatus from enjoying the necessary rest? There is such a thing as over-excitement of the organs; and to this, the central nervous system is peculiarly exposed. Who does not know the feeling of "outwatching sleep"? The over-excitement of the brain may be repeated several times at continually shorter intervals. It may be caused by emotion, by overwork of the intellect or the imagination, by bodily stimulants. A congestion of the cortical substance, of proportionate duration, undoubtedly coincides with this state of over-excitement; and this is the point from which we must set out in order to gain an insight into the etiology of the psychoses.

Congestion is usually divided into active and passive. The

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upon the morbid anatomy of the psychoses. Unfortunately the very first step in this direction, taken by *Meynert* himself, can hardly be called a happy one. He sets out from the assertion that the nucleus of a normal ganglion-cell is in some measure prolonged into its processes, and retained in them, so that it ought not to be viewed as naturally round, but rather as angular, with thorny projections. Hence the rounded form of the nucleus must be regarded as abnormal—as the first link in a chain of alterations which ultimately lead to fission of the nucleolus and nucleus, &c. It may be objected to this, that in the freshest attainable specimens of ganglion-cells, the nuclei are all of them round; so that when the nuclei, in preparations which have been hardened in chromic acid, appear to be for the most part not round, but fusiform or pyramidal, this change of form ought to be ascribed simply to the shrinking of the surrounding protoplasm, *i.e.* of the fibrous substance (*Schultze*) of the ganglion-cells.

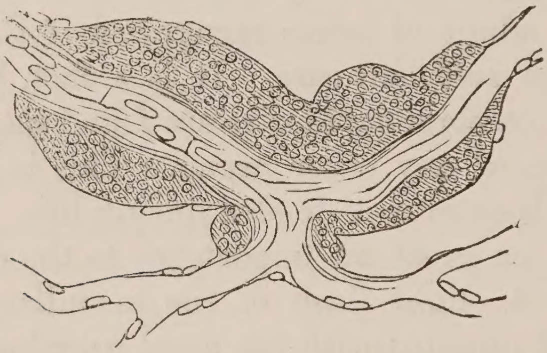
two forms, however, touch each other at several points; they often actually pass into each other, as we saw *e.g.* in § 510; or one of them may complicate the course of the other as an intercurrent phenomenon. This last case presents itself, *inter alia*, when an active fluxion, due to any of the usual causes, culminates in a great and uniform over-distension of the capillaries. The absolute excess of blood present in the affected capillary area actually hinders its own forward movement by its weight; to overcome this obstacle, there is the increased *vis a tergo* consequent on distension of the arteries, and the unhindered efflux through the veins, which are readily susceptible of dilatation; these, indeed, are the means by which the impediment is usually overcome; but they in nowise alter the fact, that during the course of active congestion a passive element developes itself, which resists the subsidence of the abnormal state. And this element will be all the more effective in proportion to the violence and duration of the hyperæmia, in proportion as this is concentrated in the capillaries, in proportion to the thinness and yielding quality of their walls. Now the capillaries of the cortex cerebri, like all the intracranial blood-vessels (§ 695) are exceptionally delicate; moreover, the peculiar relations of pressure and reaction which subsist in the interior of the skull (§ 695), enable us confidently to adopt the notion of an exclusive, or at any rate predominant concentration of the hyperæmia in a certain definite section of the vascular system; in the present case, therefore—one of functional irritation of the cortical substance—in the capillaries and arterioles of the cortex cerebri.

It cannot surprise us, therefore, to find that the passive element so introduced should manifest its worst effects in the case of cortical hyperæmia. A long-continued, or often-recurring, or very severe congestion will here, more than elsewhere, cause a sort of stasis; this, again, leads first to over-distension, then to atony of the vessels. Just as a piece of gutta-percha, when over-stretched, resumes its previous form only by slow degrees and imperfectly, so with the elastic and contractile elements of the small vessels. Once the distension has become habitual, corresponding organic changes are set up in the walls of the vessels—changes which render a return to their normal calibre—at first only a matter of time—quite impossible; and this is the first step towards making the mischief incurable.

This theory of the origin of acute psychoses has grown up gradually in my mind from the histological investigation of the cortical substance. I must leave it to the clinical physician to refer the remaining causes with which we are acquainted (*e.g.* age, hereditary transmission, cranial development, variations in the calibre of the venous apertures, diathesis, acute disease, alcoholism, sexual excesses, poverty and privation, intracranial tumours, injuries to the head, and so forth), either to increased irritability or to increased irritation of the cortical substance, or to a diminished capacity for resistance on the part of the vessels. I shall now proceed to describe the histological changes themselves, adopting the customary division of insanity into two stages, the acute and chronic.

§ 714. I. Acute conditions. These may either be appreciable at the first glance, or they may be difficult of recognition; yet they always admit of being recognised if the examination be conducted with sufficient care. It is a fact, hitherto unexplained, that the cerebral capillaries are found more empty after death than those of any other organ. This is the case even when they have been over-distended during life. We must not therefore attach too great an importance to the direct evidence of hyperæmia. A slight flush of the medullary substance, a faint tinge of red mingled with the usual grey hue of the cortex cerebri, must be taken as very significant indications; where even these are lacking, we must not jump to the conclusion that they did not exist during life. We are thus thrown back upon indirect evidence. And here the ease with which the blood escapes from the cerebral vessels comes to our aid. The problem for the histologist resolves itself into the detection of antecedent hæmorrhages. Now we find cases of acute insanity, especially of mania, in which the cortical substance is studded throughout with numberless minute extravasations, and may even present patches of red softening here and there. Under these circumstances, there can be no difficulty in proving that hæmorrhage has occurred; hence we may infer the existence of hyperæmia during life even though, as is generally the case, no traces of it may remain, and the vessels be as empty as if no drop of blood had ever flowed through them. I have already described the punctiform variety of hæmorrhage, and red softening, very fully; now therefore, I need only allude to a few peculiarities which characterise these changes as they occur in the psychoses. First then, as regards the punctiform hæmorrhages; these mostly take the form of dissecting aneurisms of the smallest veins (fig. 192); *i.e.* the blood, after bursting through the inner and middle coats of the vessel, burrows between the latter and the unruptured adventitia, forming a spindle-shaped swelling of a dark blood-red colour upon the vessel. In transverse sections, the effused blood has the form of a round drop; and as the detached adventitia may easily be mistaken for a peripheric capsule of coagulated fibrin, the detection of the central vessel is indispensably necessary to insure us against confounding these minute aneurisms with free extravasations. Not that the distinction is of any great moment; free and interparietal hæmorrhages usually occur together; only, as has been already stated, in circumscribed encephalitis the free variety, in diffuse encephalitis (to which, from our present point of view, all psychical disorders must be referred) the interparietal, predominates.

FIG. 192.



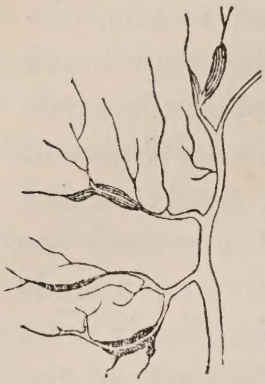
Dissecting aneurism of a minute vein, just before the latter breaks up into capillaries. The adventitia, known by its nuclei and single, sharp contour, is stripped from the inner coats by an extravasation of blood. $\frac{1}{300}$.

As for the red softening of the cortical substance which is met with in maniacal patients, stress need only be laid on its peculiar, stratified distribution. In most cases, it is the middle layer of the grey matter which is softened, so that on attempting to strip the pia mater from the surface of the brain, the outer layer of the cortex usually comes off with it; more rarely does the softening involve the outer layer itself; in that case, when the pia mater is stripped off, the surface is left quite ragged, as if ulcerated; rarest of all is the occurrence of a layer of softened tissue at the junction of the cortical with the medullary substance. I believe that this singular localisation in strata is connected with the peculiar distribution of the minute blood-vessels, discovered by *Arndt;* after entering the cortex cerebri, they break up into three tiers of capillaries, one above the other; a mode of distribution which agrees with the stages in the development of the brain, but which is, in all likelihood, more nearly related to the partition of functional attributes among the several—so sharply differentiated—strata of the cortical substance; a mode of distribution very like that with which we are familiar in most of the complex organs of the body. Granting the truth of the above assumption, the seat of softening might be held to correspond with that of the maximum intensity of functional irritation. But the hypothesis is only put forth as a guide to further investigation.

§ 715. Passing now to the more ordinary forms, in which the hæmorrhagic phenomena are less marked, I must repeat that "less marked" is not synonymous with "absent." If we take the trouble to isolate the vessels of the cortical substance, not by simply pulling them out, but by detaching the pia mater cautiously under a very gentle stream of water, we shall often be amazed to see the number of dissecting aneurisms there are, all of which would be overlooked if we contented ourselves with simply examining vertical sections; still more, to find how many less extensive, but yet unquestionably hæmorrhagic infiltrations may be demonstrated in the walls of the vessels. Horizontal sections through the grey matter are also to be recommended. The red blood-corpuscles which are actually extravasated, penetrate at once into the adjacent brain-matter to a variable depth, forming little red areolæ round the holes which contained the vessels, with their outer margin blurred and indistinct. In the grey matter of a brain which appeared perfectly normal on a superficial examination, I detected many blood-corpuscles lying free in the parenchyma; and this first drew my attention to the great frequency of minute hæmorrhages in such cases.

§ 716. The conversion of the extravasated blood-corpuscles, or of their hæmatin, into pigment and connective tissue, begins even during the acute stage. The pigment presents itself in round or elliptical flakes of various sizes, lying in the adventitia of the blood-vessels in little groups of two, four, or upwards (fig. 194). Isolated particles of pigment are also met with lying free in the parenchyma; this however, is not common; while on the other hand, a deeper pigmentation of the ganglion-cells is very usual. In many cases of acute insanity, therefore, we find recent hæmorrhages side by side with the vestiges of older ones; the combination giving a highly variegated aspect to the specimen.

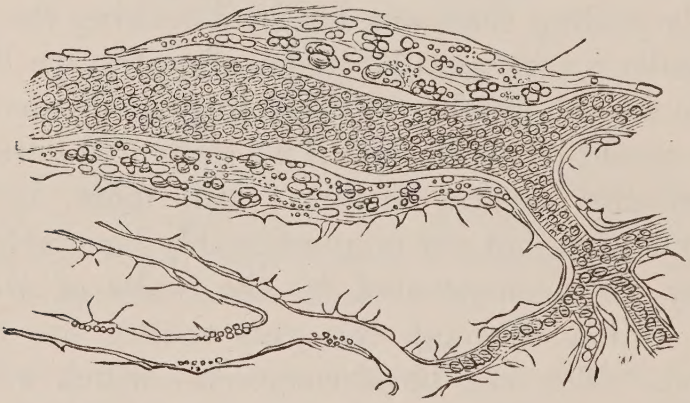
FIG. 193.



A number of dissecting aneurisms on the branches of a minute cerebral vein.

§ 717. Extravasated blood and blood-pigment are signs of antecedent congestion which are fortunately not easily effaced, and therefore all the more trustworthy. That other signs exist as well, I have already hinted, when pointing out that certain forms of disorganisation occurred after a time in the walls of the vessels, and hindered their restoration to the normal state. Of these disorganisations of the vascular walls, one only comes under the head of "acute conditions." I refer to the so-called "fatty degeneration of the capillaries"; this is not by any means a constant phenomenon in the psychoses, and it is also met with after violent and prolonged disturbance of the brain-matter due to other causes, as *e.g.* in typhus, small-pox, &c.

FIG. 194.



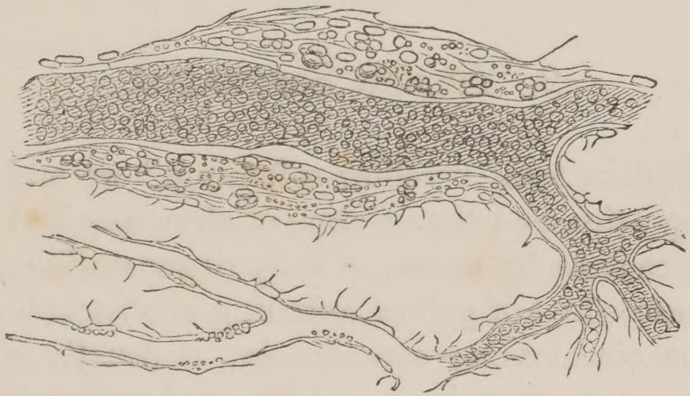
Small vein and capillaries from the brain of an imbecile. The vein shows the remains of former hæmorrhage into the adventitia, such as pigment-granules, &c. For the state of the capillaries see text to fig. 195. $\frac{1}{300}$.

The change consists in an accumulation of oil-globules immediately around the nuclei. A minute residue of soft protoplasm is always found hereabouts; the oil-globules appear in its interior; and in this way, little three-cornered swellings are produced on the outside of the vessels, each of which contains the dark oil-globules together with a single nucleus; they give the vessel a very variegated aspect (figs. 194, 196). The only question is whether we have any right to interpret these appearances as signs of degeneration. Here, if anywhere, we may suspect the oil-globules of having had another origin, *e.g.* of having been taken up by the protoplasm from the brain-matter itself; moreover, the immediate proximity of the cells which contain the oil to the nutrient fluid, might suggest the possibility of some disorder of nutrition; finally, *Leidesdorf* and *Stricker* have proved most conclusively that in traumatic inflammations, the fatty degeneration in question is compatible with very active changes in the corpuscular elements, with nuclear and corpuscular proliferation; indeed these observers seem actually inclined to draw a parallel between the granule-cells and the cells of the germ-yelk. To this I have only one objection to offer, *sc.* that fatty metamorphosis is universally admitted to be a frequent mode of degeneration in cells which are growing old, or which are badly nourished, or isolated from their organic connexion; that even the most abundant supply of nourishment is unable, of itself, to arrest their decay, as is shown by the fate of a great many white blood-corpuscles, and by the "fatty erosion" of the vessels (§ 220); that this same fatty degeneration of the vessels is an essential feature of yellow softening, which is generally due to the direct arrest of circulation and nutrition in a circumscribed portion of the brain. Whatever may be the true significance of the fatty matter in the present instance, my own observations lead me to agree with *Leidesdorf* and *Stricker*, in admitting that notwithstanding all this infiltration with oil the process may yet be of a progressive character. For what in the present case is progressively developed on the outer surface of the vessels, and what mainly contributes to their permanent disorganisation, is an actual proliferation of connective-tissue corpuscles and fibres, as will appear on glancing over the second stage of the disorder.

§ 718. II. CHRONIC CONDITIONS. The later phases of the structural alterations associated with the psychoses are much better known than the earlier ones, chiefly because they are more obvious. They may be traced in two different directions. On the one hand, the hyperæmia of the brain, when it has become chronic, gives rise to that venous stasis in the pia mater which I have described in § 699, *et seqq.*, as *Hydrocephalus externus.* The dilated and tortuous veins, the infiltration of the arachnoid with corpuscular elements, the œdema of the pia mater, the atrophy of the brain, combine to form a highly characteristic total of morbid appearances. On the other hand, the hyperæmia of the cerebral vessels is associated with a perivascular growth of connective tissue, which is propagated to the brain itself, and ultimately causes obsolescence of the nervous elements.

§ 719. Let us begin with the vessels. *Stricker* assumes that a continuous layer of protoplasm exists on the outer surface of the capillaries; this layer he believes to be responsible for the development of the vascular system, as well as for that of morbid growths which start from the vessels. This view is strikingly corroborated by the behaviour of the capillaries in acute and chronic inflammation of the brain. I allude partly to the suppurative encephalitis already described, partly to that sclerosis of the brain and grey degeneration of the spinal cord of which I shall have to speak hereafter. In the psychoses we also find a moderate increase in the amount of perivascular protoplasm; fresh nuclei appear, originating by fission of the old, somewhat enlarged capillary nuclei; finally, the thickening of the vascular wall and the increased number of cells is manifest even to an unpractised eye. The diagnosis, however, is rendered certain by the appearance of a number of fine, feebly-refracting processes of protoplasm, which give the vessel a curious, thorny appearance (fig. 195). These processes are connected with a system of juice-cells (Saftzellen) which has been developed meanwhile in the brain-substance itself, and may be recognised in vertical sections taken from a fresh brain. The addition of Canada balsam, oil of turpentine, or even of glycerine, usually makes the network invisible; the only vestiges of it which can then be detected are hardened, and therefore more highly refracting fragments, which are often enough met with. This network of juice-cells corresponds in its distribution, *i.e.* in the number of stellate elements furnished to each vascular territory, so closely to that which customarily obtains in other vascular connective tissues, that it is difficult not to suspect that some pre-existing physiological arrangement underlies the process; but this, however, no one has yet succeeded in proving. I believe, therefore, that it really depends on an actual outgrowth from the surface of the vessels; and we have an excellent precedent for this in vascularisation by the development of processes from the vessels. (§ 71). *L. Meyer*, indeed, who has done much to extend our knowledge of this subject, speaks of an actual development of new vessels in the cortical substance. This vascularisation would then be a further step in the direction inaugurated by the outgrowth of protoplasmic processes from the surface of the capillaries, the nuclear proliferation, and the development of an anastomotic network of connective-tissue corpuscles. The essential feature of the process is its restriction to the perivascular connective tissue, as opposed to the neuroglia, which remains unaltered. We shall have an opportunity of noticing a contrast precisely similar to this, when we come to speak of tumours of the brain.

FIG. 195.



Small vein and capillaries from the cerebral cortex of an imbecile. The capillaries have their walls thickened and furnished with numerous processes radiating in all directions. Most of these processes start from the nuclear points. $\frac{1}{300}$.

The changes undergone by the ganglion-cells and nerve-fibres are, as compared with those just described in the vascular apparatus, of a subordinate and passive character. Most frequent is a certain atrophy of the ganglion-cells associated with the brownish discoloration already alluded to, which is due to the imbibition of hæmatin. The complete granular disintegration, the dropsy and sclerosis, and especially the nuclear fission with which *Meynert* has made us acquainted (§ 712) occur, so far as my experience goes, only in a very limited degree. A fission of the neuroglia-nuclei is more common—but this does not seem to lead to anything beyond. We only notice that in places where we should normally expect to find only a few nuclei, there are a larger number present; here and there we find little chains and nests of nuclei. They are not in any way connected with the development of the corpuscular network described above.

The naked-eye appearances are mainly due to the pressure exerted by the œdematous pia mater upon the surface of the brain. The leathery hardness and pallor of the cortex may partly be ascribed, when present, to the interstitial growth of connective tissue. I need hardly add that the latter process is, in my opinion, the actual cause of disorganisation, the lesion which impairs the utility of the thinking apparatus.

2. YELLOW SOFTENING.

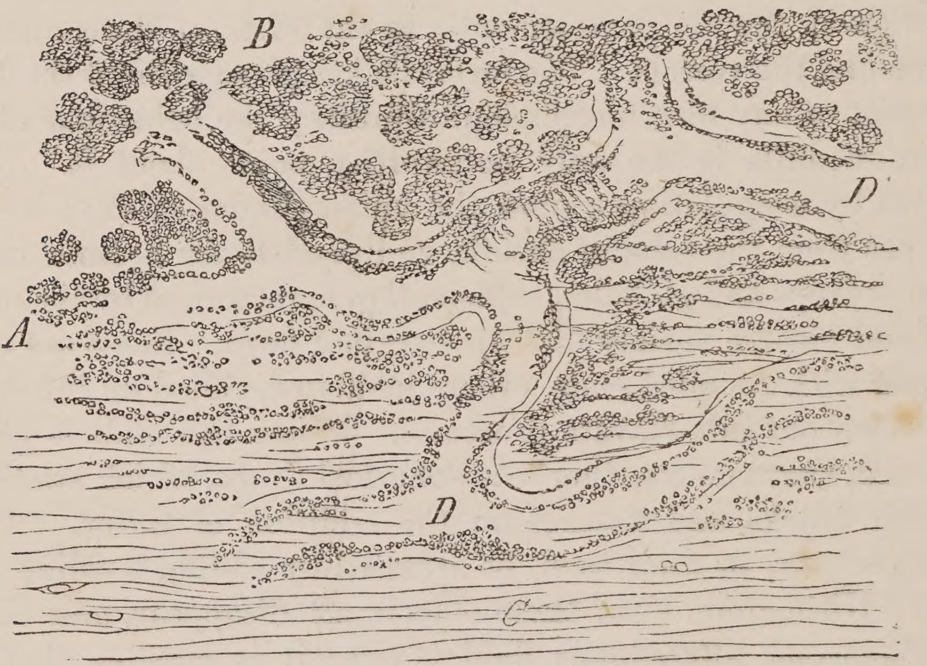
§ 720. By the term "yellow softening," we understand the total disintegration and liquefaction of circumscribed portions of the nervous centres by means of fatty degeneration. The most important antecedent of yellow softening is obstruction and total arrest of the circulation; accordingly, it usually results from acute inflammation, embolism, and hæmorrhage, such as we have been made acquainted with in the foregoing section. That embolism can cause yellow softening directly, without the intervention of punctiform hæmorrhage, is not, in my opinion, conclusively established; the possibility of its doing so must, however, be admitted for the present. Yellow softening is invariably the final term of a series, whatever may have been the sequence of the previous changes. The following sequences are perhaps the most common:—1. Embolism, punctiform hæmorrhage, yellow softening. 2. Punctiform hæmorrhage, capillary thrombosis, yellow softening. 3. Punctiform hæmorrhage, inflammation (red softening), yellow softening. 4. Encephalitis, punctiform hæmorrhage, red and then yellow softening. Yellow softening only shows that the morbid changes have reached a point at which regular nutrition is permanently arrested. Accordingly we meet with it in a great number of other conditions also.

Thus I have found the medullary layer of the anterior lobe of the right cerebral hemisphere affected throughout with yellow softening, owing to gliomatous degeneration of the grey matter round it, which had stopped the circulation through the cortex. Most tumours whose growth is central are surrounded by a zone of yellow softening, caused by the pressure of the tumour upon the neighbouring blood-vessels; indeed it is impossible to give an exhaustive summary of all the cases in which yellow softening may occur; every observer must trust to his own ingenuity to ascertain the cause of the softening in any particular case.

§ 721. The minuter details of yellow softening fall naturally under two heads; on the one hand we have disintegration and solution of the nervous elements; on the other, of the connective tissue and the vessels. The former takes place without the development of any new morphological units; the behaviour of the nerve-medulla is the only noteworthy point about it. This begins by coagulating round the axis-cylinder (§ 32); it then escapes from the tubular sheath, and persists for a time in the form of drops and globules, sufficiently characterised by the manifold and bizarre variety of their external form. Some are club-shaped with rounded ends, others lobulated, rolled up into tufts, or drawn out into clavate processes. When the slide is gently warmed, they run together into spherical drops, which swell and exhibit cracks and fissures on the addition of water. These changes may, in their turn, be arrested by adding a saline solution. Ultimately, even these objects all disappear, and only a homogeneous, albuminous fluid is left; it is possible that the nerve-medulla may be decomposed into fat and albumen, the fatty granules mingling with the rest of the oily *débris* as soon as they are set free.

The liquefaction of the connective tissue and the vessels takes place in a very different way. Here, fatty degeneration plays a leading part; it is the actual agent in the destructive process. All the corpuscular elements of the neuroglia are converted into granule-cells. In vertical sections through the edges of the softened part (fig. 196), we can easily trace the aggregation of groups of fatty granules between the nerve-fibres, until they attain the size of colossal granule-cells. These last are suspended in the fluid products of softening, giving them the peculiar colour to which the entire process owes its name. On a black ground, the granule-cells may be seen, even with the naked eye, floating about like small particles of dust. The vessels too, succumb to fatty metamorphosis. Spindle-shaped aggregates of fat-granules may be observed in the place of the capillary nuclei, and larger, confluent masses of these granules may be seen beneath the adventitia of the small arteries. I found the latter tunic (fig. 196, *D*) detached throughout, as though an interparietal lymphatic space had been opened up. The homogeneous membranes of the vessels and the basis-substance of the neuroglia undergo a direct, though very gradual liquefaction, so that the fluid products of softening come ultimately to contain nothing but fat-granules and granule-globules.

FIG. 196.



Yellow softening of the medullary substance of the brain. *A*. Junction of the softened part, *B*, with that which is still firm, *C*. *D*. A vessel undergoing fatty degeneration. $\frac{1}{300}$.

§ 722. So much for the histology of the process. The naked-eye appearances will necessarily vary according as the position of the lesion is favourable or unfavourable to the absorption of the products of softening. Patches of softening in the interior of the hemispheres cannot be obliterated, because their walls cannot collapse ; the granules may possibly be absorbed in course of time, the fluid may become clear, a cyst may be formed—but here the matter ends. Should the lesion be situated near the surface of a ventricle—as often happens in the corpus striatum—a slight subsidence of the layer of brain-tissue which separates it from the ventricular cavity may occur, and the softened patch may wholly disappear. This subsidence is much more striking when the mischief is situated in the cortical substance itself. We not unfrequently meet with cases in which the surface of the hemisphere exhibits an extensive and often multiple depression, over which the pia mater may either have collapsed, or be stretched by a simple serous effusion or even a yellow, fatty emulsion. The brownish discoloration of the brain-matter in the immediate neighbourhood points in a general way to hyperæmia and hæmorrhage as the immediate antecedents of the lesion; the precise nature of the primary mischief has not, however, been certainly established. One thing seems clear: that the final removal of the affected portion of the cortical tissue is operated by yellow softening; also, that the complete absorption of the fluid products of softening has been made possible by the very superficial site of the lesion.

§ 723. Scattered throughout our exposition of the inflammatory disorders of the central nervous system are various hints which point to an extension of the domain of fatty degeneration, and especially of the formation of granule-cells, beyond the limits of retrograde metamorphosis. Such an extension is suggested to us, *inter alia*, by the experiments of *Leidesdorf* and *Stricker* on traumatic cerebritis; by a case of fatty metamorphosis of the corpuscular elements of the neuroglia throughout the entire medullary substance of the brain, which has recently been described by *Virchow* as "encephalitis" in a new-born infant suffering from hereditary syphilis. To these we must add the discovery of granule-cells in certain parts of the spinal cord in cases of general paralysis of the insane (*Westphal*), as also the fatty degeneration of single columns of the cord, described by *Türk* as a consequence of circumscribed disease in the nerve-centres. These considerations must at any rate warn us against concluding without further evidence, that fatty degeneration and the development of granule-cells are identical with yellow softening.

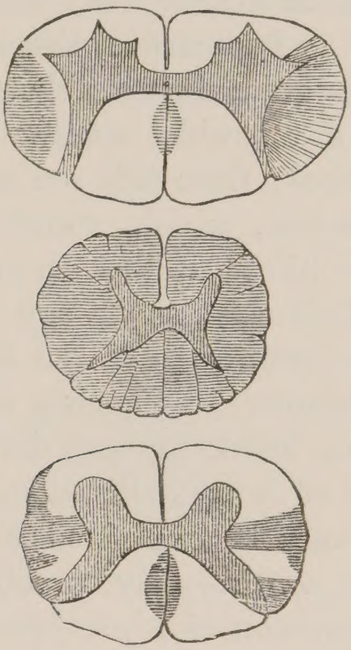
3. GREY DEGENERATION.

§ 724. Limited patches, striæ or spots, in the white substance of the brain, the spinal cord, and some of the peripheric nerve-trunks, are occasionally seen to exhibit a grey tint like that of the cortex, instead of their usual white colour; and these appearances are found to coexist with certain typical series of clinical symptoms. On the ground of the alteration in colour, these cases have all been grouped together under the common head of grey degeneration. The instinct which led pathologists to do this, was in itself a just one. For if we consider grey degeneration *per se*, we find that it is always due to the same proximate anatomical cause, *sc.* the disappearance of the medullary sheath of the nerve-fibres. Medullated fibres look white in the aggregate; non-medullated fibres look grey. It is seldom, however, that the loss of the medullary sheath is the primary and only lesion. It ought rather to be viewed as a secondary phenomenon, as the first step towards atrophy, nay, towards complete destruction of the nerve-fibres. It commonly precedes this latter change, just as decalcification precedes the dissolution of bone-tissue.

§ 725. The morbid anatomy of grey degeneration has been repeatedly subjected to scientific investigation of late years; I refer more especially to the labours of *Leyden*, *Frommann* and *Charcot*. And one result of these inquiries has been to make us distinguish more rigidly between two forms of the disorder, one of which we may call the simple and non-inflammatory, the other the indurative and inflammatory—or simple grey degeneration and sclerosis.

The simple form of grey degeneration is most common in the spinal cord. The posterior columns are more liable to it than either the anterior or the lateral ones (fig. 197). After the cord has been taken out of its sheath of dura mater and washed, we may see, to use *Leyden's* own words, "a band of a grey or greyish-white hue shining through the pia mater, and extending, as a rule, along the whole length of the cord." On transverse section, we find that the grey discoloration of the surface is due to a change in the white matter which extends into the substance of the cord. The entire posterior columns are usually converted into a reddish-grey, somewhat brawny mass. Should there be any normal tissue left, it is sharply marked off from that which has undergone degeneration; the latter, moreover, is somewhat depressed below the level of section, and yields a small quantity of clear fluid when squeezed. The degeneration usually mounts upwards from the *cauda equina*, and spreads—when viewed in transverse sections—from the periphery and the middle line behind, towards the central axis and the lateral margins of the cord; so that in cases where the degeneration is incomplete, the residue of white matter forms a lamella, which, starting from the hinder edge of the commissure, passes along the posterior horns towards the circumference. The posterior roots of the spinal nerves invariably participate in the morbid process; this fact seems to have been overlooked in many cases, otherwise carefully reported.

FIG. 197.



Unusual localisation of simple grey degeneration. In the cervical and lumbar regions of the cord (top and bottom figures), it is the lateral tracts which are chiefly involved; in the dorsal region (middle figure), the entire medulla. After *Frommann*. Natural size. Transverse sections.

§ 726. Chief among the textural alterations which underlie the simple form of grey degeneration, is an increase in the amount of the interfibrillar connective substance (cement) of the medullary columns. Whether this substance is normally finely-granular or finely-fibrillated, has not been hitherto decided. Each of these views has its adherents, and the opposite camps vie with one another in the dogmatism of their assertions. Granting for a moment that those are right, who (like myself) regard it as being of a finely-granular, quasi-protoplasmic nature in health—then a transformation of this amorphous cement into a finely-meshed fibrous network would be at any rate the first step towards grey degeneration. The meshes of this fibrous network are not, indeed, as small as those of the spongy reticulum which *Schultze* describes as normally present. It is rather produced by a shrinking or retraction of the cement, which was at first equably distributed, into certain branching lines (just as happens on the addition of reagents). In the prismatic, triangular interval between any three contiguous nerve-fibres, a tolerably stout rod is produced, running parallel to the fibres; from this rod, a countless number of minuter processes project, which, running transversely and obliquely between the fibres, unite with one another to form a delicate network.* This first, so to say preparatory stage, is followed by a peculiar outgrowth of the fibrillæ; according to *Frommann*, minute protuberances spring up at intervals, which grow larger and again break up into branches. The process reminds the observer of a crystallisation, or at any rate of a coagulation, and can only be explained by supposing that the coagulable matter is continuously precipitated—and this of course implies the admission of a previous stage, during which it was quite soft. This may shed some light on the observations of older authors, who came across considerable quantities of amorphous interstitial substance here and there. On teazing out minute shreds of the grey degenerated parenchyma with needles, the felted web of fibres readily breaks up into a number of roundish balls, which, on more careful investigation, exhibit a firmer centre containing a nucleus, from which the countless fibrillæ all appear to radiate (fig. 198). Every one of these centres corresponds to one of those branched and anastomosing connective-tissue corpuscles, which are distributed at regular intervals throughout the nerve-tissue. We know that these elements are most numerous at the circumference of the cord, getting fewer in number towards its centre. This agrees with the appearances presented by the degenerated medulla in transverse sections; for we are able, by continued rubbing with the covering-glass, even without the help of needles, to separate the individual balls from one another to some extent, when they are seen to be smaller in size towards the periphery, more bulky towards the centre of the cord. In the former situation, they are continuous with the innermost layer of the pia mater, and may be regarded as a sort of "irradiation" of supporting fibres into the nervous matter (*Henle* and *Merkel*). The grey degeneration also progresses demonstrably from the circumference of the cord as its base, and spreads gradually towards its centre.

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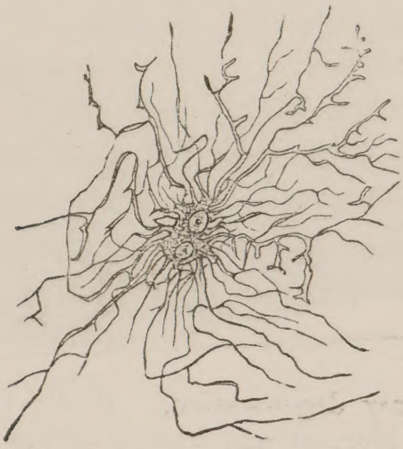
* *Frommann* was the first to demonstrate these exquisite networks. He finds them also in the normal cord; but here I consider them a result of the shrinking caused by reagents.

FIG. 198.

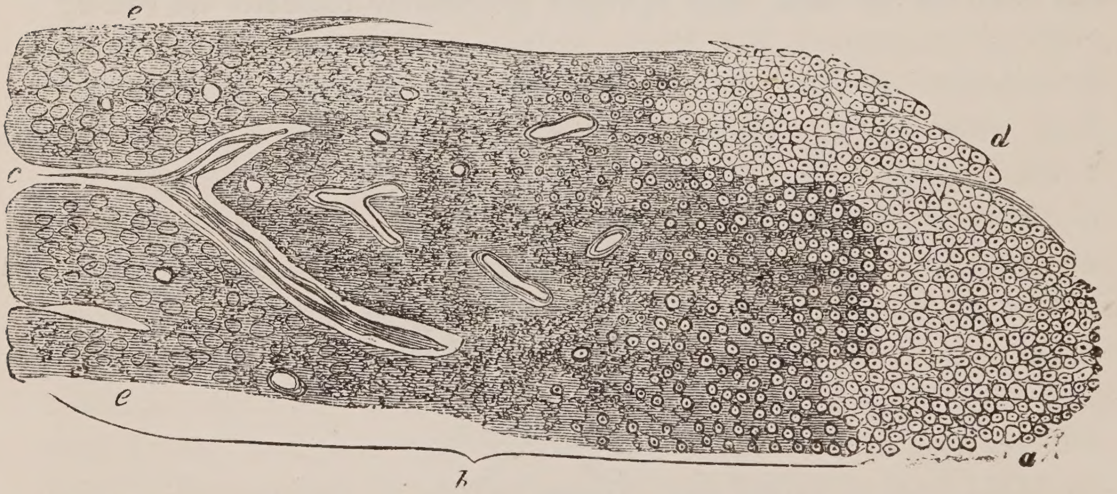


Nucleated connective-tissue corpuscles, studded all over with little tufts of fibres; they were obtained by teazing out a portion of a spinal cord affected with grey degeneration. $\frac{1}{300}$.

All this compels us to suspect that the chief part of the disease is developed in close connexion with this pre-existing system of fibrous connective tissue—in fact that the morbid change sets out from this. The fibroid metamorphosis of the nerve-cement proves the chemical and morphological identity of the amorphous interstitial substance with the fibrous interstitial tissue; their physiological relationship is thus established, and the belief confirmed, that the neuroglia is really a connective substance, and not, as is still alleged by some anatomists, of nervous character.

§ 727. Let us now consider the second factor in simple grey degeneration, *i.e.* the obsolescence of the nerve-fibres in the affected columns of the cord. The fact that this change is co-extensive with the advance of the interstitial tissue, proves that the two phenomena are causally connected; but it remains undecided, whether the disappearance of the nerve-fibres is the cause or the consequence of the overgrowth of the neuroglia. For my own part, I cannot well conceive of the degeneration of the nerve-fibres as the primary phenomenon; atrophic changes of the nerve-tubes, artificially excited in peripheric nerves, never give rise to any analogous effects in the perineurium. On the other hand, we can call to mind innumerable examples of atrophy of nerve-fibres being caused by external pressure. I quite agree with *Frommann* in believing that the growing network of connective tissue forces its way into the space assigned to the nerve-tubes, and thus ultimately causes their disintegration. As regards the finer details of the process, I think I have observed that the neurilemma, at an early stage, becomes fused with the advancing connective tissue, while the medullary sheath breaks up, and the axis-cylinder alone continues to resist. The thicker axis-cylinders retain their form for amazingly long periods, and may often be discovered in parts which have

FIG. 199.



General view of grey degeneration. Partly taken from *Frommann*. $\frac{1}{50}$. *a.* Normal parenchyma of the spinal cord. The circular bodies are the nerve-fibres in transverse section; *b.* The region of grey degeneration; *c.* A vascular cleft with its vessel; *d.* Limit of the grey matter (posterior horn); *e.* Circumference of the column, abundantly infiltrated with corpora amylacea.

apparently succumbed a long time before to degenerative changes (fig. 199).

§ 728. The behaviour of the vessels in the simple form of grey degeneration is of very subordinate importance. True, they are never quite normal; but the alterations they present are neither important nor constant. Perhaps the most common among them, in the greater vessels, is a marked thickening of the adventitia, which comes to consist of wavy lamellæ of connective tissue ; in such cases the adventitia has taken part in the hyperplastic change affecting the neuroglia ; here and there, too, an accumulation of fatty and pigment-granules may be detected on the smaller vessels, as well as a peculiar rigid, homogeneous, glistening state of the vascular walls—a condition not unlike amyloid infiltration, but which fails to yield the typical reaction with iodine.

A phenomenon which has long been known, but of whose histological significance we are still quite ignorant, is the presence of *corpora amylacea*, often in large numbers, in the degenerated parts. These bodies are constantly met with in simple grey degeneration. They are most crowded near the circumference of the organ, in the part which has been affected for the longest time (fig. 199), and along the course of the larger vessels ; they are not entirely absent, however, even in those parts where the degeneration is just beginning. *Rokitanski* held that they were derived from the fragments of disintegrated medullary sheaths ; recently however, the view which I believe to be the true one, that the *corpora amylacea* are really degenerated cells, has been gaining ground. The uniform size of these bodies, the occasional presence of an unaltered nucleus in their interior, their whole mode of distribution, make it almost certain that they are produced by amyloid infiltration of the round-cells of the neuroglia, the "granules" of the normal medulla.

§ 729. The second form of grey degeneration, which I have termed "inflammatory induration," has a wider range than the first variety. The whole of the white substance of the central organs is liable to this morbid change ; not only the medullary columns of the cord, but also the centrum of Vieussens in the brain, the corpus callosum, the fornix and the fimbria, the septum lucidum, the optic tracts, the corpora geniculata, cerebral peduncles, pons, and medulla oblongata. The mischief starts from numerous centres, the smallest of which are about the size of a pin's head, while the larger ones extend through entire sections of the white substance, *e.g.* through the whole fornix, or a tract an inch long, of the lateral columns, nay, even of the whole cord. Inasmuch as the process which underlies the morbid appearances always causes a marked shrinking of the affected parts, the medullary layer of the central organs is proportionately distorted; should the change be situated in alternate patches of the lateral columns, the spinal cord comes to present a series of elevations and depressions, which give it quite a sinuous aspect; should the whole thickness of the cord be involved, it appears to be constricted at the affected point; hence the appearance of a very striking deformity, particularly if the adjoining portion of the cord be quite normal. (Cf. the beautiful figures in *Cruveilhier.*)

§ 730. An attentive examination of the smallest of these grey foci leads to the curious discovery, that they have all got a red spot or line in their centre—a distended blood-vessel, cut across transversely or obliquely. The microscope shows that all these vessels, together with their finer ramifications, are in a state which we should not scruple elsewhere to call one of chronic inflammation. The adventitia is made up of concentric layers of round-cells, often five deep. The calibre of the vessel, far from being narrowed, is positively dilated—a phenomenon which must be partly ascribed to a change in the middle coat. I have often been able to assure myself that the smooth muscular fibres of which the middle coat of these vessels consists, do not present their usual form and disposition. Changes of a progressive character may also be detected in the capillaries. Their walls are surrounded with cells, which have either migrated from their interior, or have originated by proliferation of their nuclei.

In these alterations of individual vascular tufts, I see the first anatomical element of the disease. The second consists in a fibroid metamorphosis and overgrowth of the neuroglia, in every way similar to that described in § 726, from which it differs only in the more important part played by the corpuscular elements of the connective tissue. The stellate corpuscles of the framework, which in this, as in the former case, act as "centres of crystallisation" (if the term may be allowed) for the fibroid development, take the form of multinuclear giant-cells, while the countless, often long and lustrous fibres which spring from their circumference, give them a very singular and monstrous aspect. The round-cells of the neuroglia also proliferate, forming a denser infiltration round the borders of the diseased part. They ultimately succumb, however, to fatty degeneration. They swell, and form granule-cells of relatively large size; as such, they are found scattered in great numbers among the felted fibres of the diseased part; finally, they break up into oily *débris*, and are absorbed. The disintegration of the nerve-fibres takes place just as in simple grey degeneration. *Corpora amylacea* are either not produced at all, or only in small numbers. The ultimate product is a fibrous web, soaked like a sponge with a mucoid fluid in which a few free nuclei and small uninuclear cells are suspended. This fluid may be squeezed from the freshly cut surface; but in proportion as the fibrillæ of the web continue to shrink, the fluid disappears and the fibres approach one another until they finally come into contact, leaving no interstices; and thus arises the extremely unyielding, tough, dry tissue, of which the cicatricial or fibroid patches remaining after the termination of the process are made up.

§ 731. In conclusion, I must not omit to mention that there is another simple, not fatty, form of atrophy of the peripheric nerves, which depends solely upon a disappearance of the medullary sheath, and hence also gives rise to a grey discoloration of the affected part. This is seen, *e.g.* in the optic nerves, following disease of the retina, or extirpation of the optic bulb; in the optic tracts, as a result of gliomata of the thalamus, or other cerebral tumours by which the tracts are compressed, &c.

The grey degenerations which occur in the medulla oblongata, associated with all sorts of disorders in the area of distribution of the cranial nerves, have not been adequately investigated hitherto. In one case of masticatory spasm, I found a sclerosis, due to the development of connective tissue, starting from the floor of the fourth ventricle; in several cases of epilepsy, I have noticed a fibroid thickening of the pia mater over the anterior aspect of the medulla oblongata, which had not, however, penetrated into its substance. It was associated with an intense degree of brownish pigmentation.

4. TUMOURS.

§ 732. Throughout *Virchow's* work on tumours, that imperishable monument of German science, we notice a continual endeavour on the author's part, now expressed, now implied, to accustom his pupils to a less abstract way of looking at the individual species of tumours, and to point out the important influence which the seat of a growth, *i.e.* the tissue in which it originates—exerts upon its anatomical and physiological properties. Whoever is not content with a mere superficial determination and labelling of a tumour, but is used to explore its intimate structure and composition, and to compare them with its vital peculiarities, will fall in with *Virchow* in hoping for the best results from this method, as regards the ultimate reconciliation of that unhappy discrepancy which still subsists between the legitimate claims of clinical practice and the limited means at the disposal of morbid anatomy. The instinct of the practical physician points in the same direction; for he grounds his prognosis quite as much on the seat of a growth, as upon its minute structure and development. Meanwhile it would be foolish to give up the results we have already obtained, for the sake of a knowledge which, however tempting, is still very remote and shadowy, and which can only be reached by the painful searching of many years. I propose, in the present chapter, to do something in the direction indicated above, by dividing the tumours of the nervous system into three groups, according to their place of origin:

a. Tumours which spring from the free surfaces of the meninges and cavities of the nervous system.

b. Tumours which set out from the perivascular sheaths.

c. Tumours which start from the neuroglia (perineurium).

a. Tumours growing on the free surfaces of the interstitial spaces of the nervous system.

§ 733. The arachnoid sac, that of the spinal dura mater, and the cerebral ventricles, present large surfaces on which a series of HISTIOID TUMOURS occur under the common form of flat, rounded protuberances. The similarity of external form is accounted for by the similar development of all these growths. They are all of them efflorescences, in the narrower sense of the term. It is only the most superficial layers of the wall which are concerned in their production. For a time indeed, the endothelium may be the only tissue affected by the morbid irritant. Its elements are in a state of active nuclear and corpuscular proliferation in the neighbourhood of all these tumours. But the growth actually starts from an "exudation of plastic lymph (embryonic tissue) from the superficial pores." I purposely adopt this rather antiquated mode of expression, because it really does give a very pregnant idea of the process. The cells which crop up on the surface, speedily combining to form little hummocks of embryonic tissue, are emigrants. We have no right to assume that they are produced by any formative irritation of the connective-tissue corpuscles at the seat of mischief. Such a hypothesis would have to contend with the lack of any demonstrable fission of these corpuscles, and with the general behaviour of the connective tissue, whose fibrous bundles, in the very region of the growth, continue for a long time absolutely intact, and only begin to be loosened and dissociated when the tumour has reached a considerable size. Even then, the loosening is due to an infiltration with morbid elements *ab extra;* as though the tumour, growing at first in an outward direction only, began to grow inwards also, at a later period. The real course of events, however, is probably this; the corpuscular masses destined for exudation are dammed back on their way to the surface, in the interstices of the connective tissue, owing to the resistance offered by the neighbouring organs to the increase of the tumour. The latter can only adapt themselves gradually to their altered circumstances, by undergoing atrophy and loss of substance at the point where the pressure is most severe, a loss of substance proportionate to the size and shape of the tumour. The more time they have for the purpose, the more complete will be their adaptation. Hence the infiltration of the connective tissue is always directly proportionate to the rapidity with which the tumour grows (spindle-cell sarcoma); it is least manifest when the tumour increases most slowly (Pacchionian granulations, lipomata, &c.). If the tumour met with no resistance from neighbouring organs—if it grew into an open space—the infiltration would not occur at all; in fact it is absent even in those tumours which protrude into the ventricles.

§ 734. The PACCHIONIAN GRANULATIONS of the arachnoid may be regarded as in some sort the prototype of this whole group of tumours. According to *L. Meyer*, the development of these minute, but numerous milk-white projections, which are chiefly found on either side of the longitudinal sinus along the edges of the cerebral hemispheres, is immediately related to the so-called "respiratory movements" of the brain. The hemispheres, when filled with blood, move from their position just as the lungs do, when filled with air. The displacement is null at the base, where the brain is firmly attached; it is greatest along the upper angles of the hemispheres, which are farthest from the fixed points. Under a low magnifying power, the Pacchionian granulations appear to consist of groups of papillæ, some of which are simple, while others bifurcate once or even twice; they become pedunculated as they grow bigger, but without ever separating entirely from their place of origin. They are absolutely non-vascular, and consist mainly of a wavy connective tissue, poor in corpuscular elements, which grows directly from a thin but incessantly renewed layer of subepithelial embryonic tissue. The epithelium with which they are clothed consists of several strata, in marked contrast to the normal epithelium of the arachnoid membrane. *Meyer* actually discovered epithelial granulations in the neighbourhood of these tumours, so that the active participation of this element is beyond all doubt, although the connective tissue is the chief factor in their development.

The tumours which grow from the surface of the dura mater are far more various. In the first place, we have a SPINDLE-CELL SARCOMA which grows by preference from the dura mater at the base of the brain, forming tuberculated and often very extensive protuberances near the *clivus* and *sella Turcica*, compressing the cranial nerves at their point of exit, and the adjacent parts of the brain; the compression leading first to irritation, then to paralysis, and lastly to destruction of the parts. The same variety of sarcoma is also met with on the dura mater of the cord. It is characterised by the large size and perfect evolution of its nucleated spindle-cells, which are arranged in bundles, but may readily be separated by teazing with needles. This quickly-growing form of sarcoma is closely related to two other tumours of slower growth, which were first differentiated by *Virchow's* skill; I refer to MYXOMA and psammoma of the dura mater. The former of these is of most clinical importance when it affects the dura mater of the cord; for this is its most common seat, and it proves dangerous by compressing the spinal marrow; whereas in the cranium it is usually situated on the convexity of the hemispheres, and accordingly belongs to that set of tumours to whose presence the brain is best able to accommodate itself. The PSAMMOMA is a tumour with a basis of connective tissue, or even of mucous tissue, distinguished by its containing globular calcareous concretions. In the pineal gland, where these concretions are almost physiological, they are commonly known as "brain-sand," whence the term "psammoma" (ψαμμος, sand). *Virchow* believes that the psammomatous concretions result from the progressive deposition of earthy salts, first in the centre, and then towards the circumference, of a concentrically-laminated, non-cellular, organic matrix. We should thus have to exclude from among the psammomata a whole series of precisely similar tumours, in which the concretions are due to the incrustation of corpuscular elements (fig. 200).

Finally, small lipomata have occasionally, though rarely, been met with on the inner surface of the dura mater and the ventricular ependyma. These protrude from the surface *ab initio*, and never force their way deeper into the substance of the brain.

b. Tumours which set out from the Perivascular Sheaths.

§ 735. Let us first of all consider somewhat fully the soil in which the development of this great and important class of tumours proceeds. We have already become familiar with the perivascular sheaths as favourite localities for morbid growth in inflammation and in miliary tuberculosis. We have seen both pus-corpuscles and tubercle-cells originating on the surface of the vessels and forming swellings upon them. We were hampered in our decision as to the source of these elements by the possibility of their being emigrant leucocytes; and we resolved to view the pus-corpuscles as emigrant blood-corpuscles, and the tubercle-cells as autochthonous elements. The latter theory was based on direct observation. We were able to assure ourselves that in the development of the miliary nodules the cells of the adventitia underwent division, forming the bulk of the tubercle. These cells must therefore be regarded as actually entrusted with the neoplastic function. We may therefore inquire what these corpuscular elements of the adventitia really are?

The adventitia of the cerebral vessels is a homogeneous membrane with alternating nuclei. By treatment with silver nitrate it may be made to display Recklinghausen's lines, which divide it into lozenge-shaped areas, each with a central nucleus. The outer surface of the cerebral vessels is thus clothed with an endothelium corresponding to the epithelium of the lymphatic vessels. If the opposed surface of the brain-matter were clothed with a similar layer of epithelium then the theory of *His*—that the cerebral vessels run in lymphatic spaces—would stand on an incontrovertible basis. Although this conclusive proof is wanting, I regard all doubts on the subject as misplaced, since I find that in the development of morbid products the epithelial cells of the adventitia exhibit all those peculiarities with which we are now familiar in the case of the lymphatic epithelia, and that in a very high degree. For after undergoing proliferation by fission, they readily furnish material for the construction of the various kinds of tumours. They do this, however, under a predominant tendency to the development of a contrast between epithelium and connective substance; we shall see how benign and malignant epithelial growths, cancers and papillomata of the most various kinds, are developed upon this basis; besides these, however, syphilitic gummata and sarcomata are also met with in the form of perivascular tumours; but no adequate evidence has in my opinion been furnished as yet concerning the latter of these two formations.

The outer surface of the cerebral vessels is continuous, at the periphery, with the under surface of the pia mater—in the ventricles, with the surface of the choroid plexuses. The under surface of the pia mater is clothed with the very same lymphatic epithelium as the vessels; accordingly it comes under the same category. The surface of the choroid plexuses is coated with a highly-developed and characteristic epithelium, which has already been alluded to (§ 702). It shows a very marked tendency towards the evolution of higher epithelial forms. I may add that these forms serve in some degree as types for the elements composing all those epithelial growths which set out from the under surface of the pia mater, or the outer surface of the cerebral vessels.

The dura mater presents analogous conditions on its external surface—that turned towards the cranial bones; numerous vessels cross from it to the skull, and dip into the Haversian canals of the bone. Shall we ever find lymphatic spaces here also? For the present, I can only insist upon the singular analogies between the behaviour of these vessels and those of the brain in the development of cancerous and syphilitic tumours—analogies about which I shall have more to say hereafter.

The mode of growth is the same, roughly speaking, for all the tumours belonging to this group; the morbid formation makes its appearance in its proper character on the affected surface, and then spreads uniformly in a horizontal direction; the increase of the tumour in thickness being devoted to filling up the space between the productive points of the irregularly curved surface. This space is originally occupied by the parenchyma of the nervous organ, *e.g.* by the cerebral substance. But this takes no share in the growth; it simply wastes and disappears; so that the tumours invariably have the character of foreign bodies, quite distinct from the nerve-centres, and intruding into them from without. They cause death, either by destroying vital parts of those centres, or by setting up inflammation and hæmorrhage in their neighbourhood. Meanwhile, they may attain to a very considerable size without causing death; this is not wonderful when we remember the great capacity of the brain for accommodating itself to slow and localised atrophy.

§ 736. The first of the tumours belonging to this group is the CARCINOMA CEREBRI SIMPLEX. It commonly grows from the under surface of the pia mater. Even such tumours as appear to lie free in the centrum of Vieussens are usually connected at some point or other with the pia mater lining an adjoining sulcus; still, tumours wholly isolated, attached only to the vessels, are also found; these, however, are always small and always metastatic. The origin of the cancer from the corpuscular elements of the surface from which it grows, may be most satisfactorily traced at the edges of the nodule, particularly where the tumour extends along the vessels into the substance of the brain. The growing zone is about a line in breadth. It is bounded externally by the normal brain-tissue, internally by the fully-formed part of the tumour; to the naked eye, it presents the appearance of a zone of liquefaction, because a great part of the cerebral substance is destroyed by fatty degeneration. By treatment with chromic acid, we may, as is well known, cause the central parenchyma to shrink away from the vessels, and so make the lacunar spaces destined for their reception appear larger than they really are. Accordingly, this is the best method to employ in the present case, where our main object must be to distinguish the vessels with their appendages from the cerebral parenchyma. It enables us to follow the alterations in the former step by step. The production of large corpuscular aggregates by the proliferation of each single element of the adventitia, forms the starting-point of the disease. The newly-formed cells are large and rich in protoplasm; they are each provided with a nucleus and nucleolus, and present an unmistakeable likeness to the epithelial elements of the choroid plexuses. They are not so much laminated, as rolled into balls; in the centre of the ball they are more spherical, towards its surface more spindle-shaped. The spindle-cells of contiguous aggregates unite to form incomplete fibrous bands, and so constitute those finer septa which usually subdivide the larger alveoli of every carcinoma. The stromal trabeculæ of the first order consist here, as everywhere else, of the residual portions of that parenchyma which is destroyed by the cancer. The destruction of a great part of the cerebral substance by fatty metamorphosis has already been mentioned. What is left is merely a narrow bridge of tissue, consisting of fine, parallel fibres, passing between every pair of much dilated vascular clefts, and containing a limited number of smooth nuclei. Whether these cylindrical, lustrous fibrillæ are the residue of axis-cylinders or metamorphosed neuroglia, I will not take it upon me to decide; but I believe the latter to be the case. If we trace these fibrous bands deeper into the tumour, we see them gradually becoming more and more homogeneous, until at last they pass directly into the main trabeculæ of the stromal network.

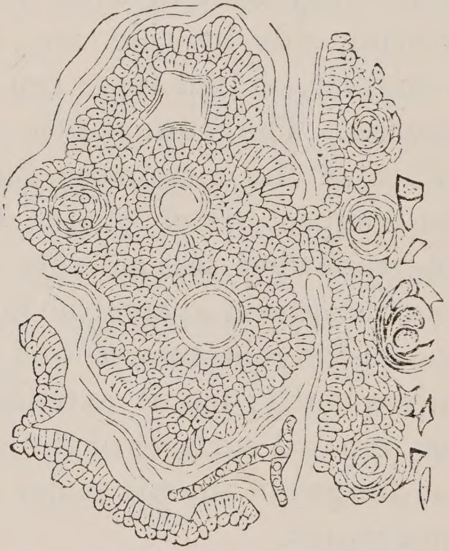
The further increase of the tumour is mainly due to corpuscular proliferation. The stroma here and there shrinks into threads and lamellæ of extreme tenuity, the intervening spaces being filled with cells rolled up into huge nests. It is noteworthy that the vessels, although the starting-point of the disease, are for the most part obliterated; it is only the largest ones which are pervious to injection, while the rest waste away into slender bands of connective tissue. When they escape utter dissolution, they form a second trabecular network, very curiously interwoven with the stromal system of trabeculæ, without however blending with it. Whoever has been engaged in pencilling out specimens of cerebral cancer, must have been struck with the appearance of this double stroma; it so happens, however, that I have not succeeded in finding any mention of it.

§ 737. Cancer of the brain, when it occurs as a primary growth, might be termed "a fungus of the pia mater;" this would indicate its close relationship to FUNGUS OF THE DURA MATER. Not only are they alike in their textural characters; they are found growing side by side, nay, even passing continuously into one another, so that there can be no doubt about their intimate connexion. The fungus of the dura mater springs from the outer surface of the membrane, forces its way along the vessels into the compact tissue of the bone, destroys the *tabula vitrea*, extends somewhat less actively in the diploë, but ultimately perforates the outermost compact lamella of the cranial bones; protruding as a fungoid tumour and pushing the scalp before it. Not unfrequently, too, it extends inwards through the dura mater; the opposed surfaces of the arachnoid are glued together, and then a fungus of the pia mater becomes associated with that of the dura mater.

§ 738. Next to genuine cancer stands one of those oncological curiosities of which there are so many in the brain; a tumour which combines the structure of an epithelioma with the harmlessness of a wart or fibroid thickening; the CHOLESTEATOMA of authors, or PEARL CANCER (Perlkrebs). This is a squamous epithelioma, whose cellular cylinders are wholly converted into a mass of pearly nodules with a silky lustre; it is usually situated at the base of the brain, projecting from the hollows between the central (pons, Medulla oblongata) and the lateral (hemispheres of cerebellum, under surface of cerebral lobes) parts of the organ, and forming tumours occasionally bigger than a walnut. It is invested by the arachnoid; on its other side, it is in immediate contact with the brain substance; its origin must therefore be sought either in or underneath the pia mater. The rarity of pearl cancer in the substance of the brain indicates that its development, like that of simple cancer, starts from the lymphatic spaces and perivascular sheaths. As regards the finer details of its evolution, *Virchow* speaks of outgrowing club-shaped cylinders of cells, of epidermic globes embedded in the meshes of the pia mater, &c.—facts which accord very well with the hypothesis that the cells of the tumour are generated by the inner surface of the lymphatic spaces, *sc.* by their epithelium.

Closely allied to pearl cancer is a rare tumour of the third ventricle, consisting of globes and cylinders of epithelial cells, embedded in a very bulky stroma of mucous tissue (fig. 200).

Fig. 200.



Epithelioma myxomatodes psammosum. For details see text. $\frac{1}{300}$.

At first sight, the tumour looks like a very soft myxoma, differing only in containing very hard granules of a milk-white colour. These granules are calcified pearly globes. On putting them under the microscope and squeezing the covering-glass gently, they break up into conchoidal fragments which correspond to the calcified cells. Around them we notice the more recent epithelial proliferations, forming tubes and nests just as in all true cancers.

The only peculiarity of all the above varieties is that they are purely local; even the fungus of the pia mater seldom giving rise to metastatic deposits.

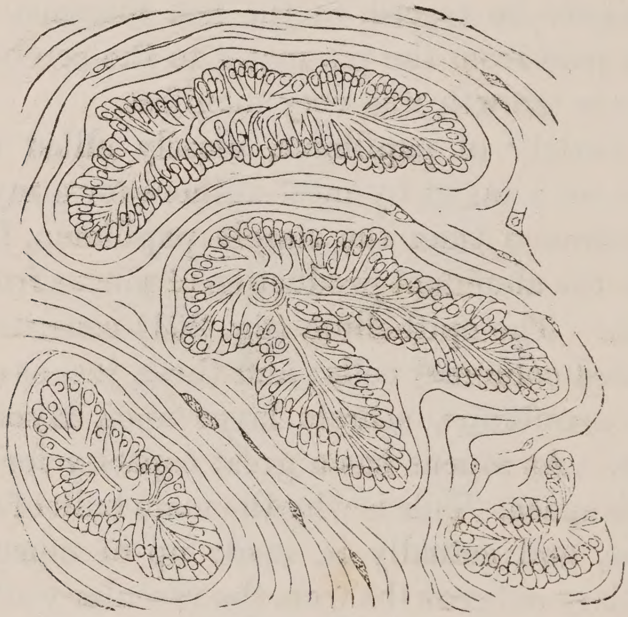
§ 739. The next series of tumours is principally characterised by "an outgrowth of the proliferating surface in the form of true papillæ." My first experience of the PAPILLOMA PIÆ MATRIS ET VASORUM was in the cerebellum. A spheroidal tumour about the size of a pigeon's egg had established itself between the pia mater and the left cerebellar lobe, in which it had excavated a hollow corresponding to itself in size and shape. The substance of the growth was reddish-grey, translucent, soft and tremulous. When teazed out, it was seen to consist of a vast number of branching papillæ, each of which contained an axial blood-vessel, a very small modicum of connective tissue, and a double coat of epithelium, whose outer layer was made up of short and thick columnar elements. The papillary stroma could everywhere be traced, in the last instance, to the blood-vessels which pass from the pia mater to the cerebellum, so that the origin of the growth was very manifest.

Another variety of papilloma, closely allied to the above, seems to have been taken by most authors for a myxoma. It is much more common than the simple papilloma, from which it differs only in the abundant production of mucus from the surface of the papillæ. The epithelium (fig. 201) consists of very long and well-formed columnar cells; and these, just as on the surface of a mucous membrane, secrete layer upon layer of a viscid, glassy mucus. As mucus has a great capacity for expansion, it requires much space. This is why the main bulk of these tumours appears to be, and actually is, made up of mucus, the almost isolated papillary outgrowths from the vascular walls being easily overlooked amid the mass of mucus. The growth, which may be called a PAPILLOMA MYXOMATODES, is usually multiple. In one case I found a tumour as big as a hen's egg in the region of the *pes hippocampi majoris*, where it had sprung from the vessels of the choroid plexus which penetrate into the brain at this point, and had filled the entire cavity of the descending horn. Several smaller tumours were scattered over the surface of the hemispheres, lying embedded in the cortical layer just like simple papillomata.

§ 740. The gelatinous degeneration of the cortex cerebelli described by *Billroth* must be viewed as a pure MYXOMA of the perivascular sheaths. The naked-eye appearances of the tumour closely resemble those of the cerebral papilloma described in the foregoing section. Under the microscope, we see a simple degeneration of the adventitia—a development of a comparatively thick sheath of mucous tissue round all the vessels which penetrate into the brain from the pia mater. The nervous parenchyma between the vessels is destroyed. The thickened vessels then coalesce to form a transparent, glassy, pale reddish-grey mass, occupying a superficial depression of corresponding size.

§ 741. Whether this gelatinous degeneration of the perivascular sheaths is or is not connected with constitutional syphilis, cannot be decided by this one observation. Thus much is certain, that true SYPHILOMA of the nerve-centres is more nearly related to this, than to any other kind of tumour. I have so often described syphilitic gummata as made up of highly-corpusculated embryonic tissue with an abundant mucoid basis-substance, that I need not go into the matter again. It is less known that syphilomata of the brain approximate to the type of the tumours we have just been discussing, in their development from the perivascular sheaths. Gummata are usually found near the surface of the brain at its base, more rarely in its interior. They reach the size of a walnut, or even of a hen's egg. In their interior we usually come across several cheesy patches, while their circumference is made up of soft, jelly-

FIG. 201.



Papilloma myxomatodes, growing from the vessels of the cortex cerebri. The vascular papillæ are separated from one another by broad bands of stratified mucus. $\frac{1}{300}$. (Cf. with this and the previous figure, the dissertation of *Le Blanc*; Beitrag zur path. Anatomie der Hirntumoren. Bonn, 1868.)

like, and very vascular tissue. Sections through hardened specimens show that the highly corpuscular parenchyma of the tumour is concentrically arranged round the vessels; *Virchow* succeeded in demonstrating this fact even in parts which were already cheesy. On the opposite side, where the growth projects towards the brain or its membranes, we find that it advances along the perivascular sheaths, in the interstices which lodge the vessels, without any active implication of the neighbouring tissues. It is not often, indeed, that we have an opportunity of studying the process in an absolutely unequivocal form; for the gummata are nearly always surrounded by every variety of softening, of inflammatory and apoplectic changes, which hinder due investigation.

c. Tumours which start from the Neuroglia.

§ 742. I have elsewhere (§ 687) given my opinion concerning the textural peculiarities of the neuroglia; here therefore I need only say, that tumours of the neuroglia start essentially from its corpuscular elements. The small, round, and still enigmatical corpuscles which are briefly termed the "granules" of the nerve-cement, are capable of producing large and continuous aggregates of cells by repeated multiplication—aggregates which present themselves to us in the form of tumours.

§ 743. Let us begin with the tumour to which *Virchow* has given the name of GLIOMA. This was formerly known as a sarcoma, and I should not hesitate to retain the old name but for the fact that the local influence of the parent-soil makes itself felt in these sarcomata to so exceptional a degree, as to justify their right to a special name. One of the most striking peculiarities of glioma might be included in its name, if we were to call it a "gliomatous degeneration of a particular portion of the brain." If we have a glioma before us, we are able, as a rule, to say precisely—that this or that segment of the brain, *e.g.* the optic thalamus, the corpus striatum, the anterior part of the centre of Vieussens, a large piece of the cortex cerebri—has been transformed into the glioma. The parts retain their main outlines, but they have lost all their textural peculiarities; the gliomatous tissue having replaced all the elements of their proper structure. Spheroidal or nodular gliomata are never met with; indeed it is often very difficult to ascertain what the shape of a glioma really is, partly because it hardly differs in colour and consistency from the normal tissues whose place it fills, partly because it passes very gradually into the healthy parts around it. The first of these points is a great puzzle to me. I have in my possession a glioma occupying the place of the left optic thalamus and corpus striatum, and consisting throughout of true glioma-tissue (round-cells arranged in bundles and fibrous tracts), and which yet gives to the naked eye the impression of a simple true hypertrophy of the optic thalamus and corpus striatum. The grey and white matter alternate as usual, and yet I can find neither medullated nor non-medullated nerve-fibres, nor yet ganglion-cells. So again in a glioma of the cortical substance of the right anterior lobe of the cerebrum, preserved in the Zürich collection, the agreement of colour between the diseased and the healthy parts is most striking, although the former consist entirely of small spindle-cells and round-cells. We can only suggest, by way of explanation, that the increase of the glioma depends essentially on infiltration, and that the normal structure continues accordingly to regulate that of the morbid products. The vessels seem for the most part to be retained. Hence the tumour produces all the effect of a sarcoma, when examined in section. The only peculiar feature about it is that the cells are on the whole very small, like the ordinary "granules" of the neuroglia; this would be at least singular in a common round-cell or spindle-cell sarcoma. Still, glioma and sarcoma are very closely allied; in some gliomata we find parts where the cells are larger than usual; I have even come across spindle-cells 0·4 mm. in length and of corresponding thickness (*Glioma sarcomatodes*). Their relationship comes out strongly in their varieties also. *Virchow* has taught us to recognise a *Glioma myxomatodes* which passes into a pure myxoma by a series of imperceptible gradations. Hæmorrhagic glioma I have myself had several opportunities of examining. It is characterised by its relatively wide blood-vessels and by a tendency to bleeding, which always occurs in the centre of the tumour. The mass of blood poured out may be so great as to lead us to think, from the symptoms during life, and even—at the first glance—on the post-mortem table, that the case is one of hæmorrhagic apoplexy. The tumour is often mashed up, leaving only a narrow zone which environs the pool of blood; still, this is enough to betray the original nature of the mischief.

Gliomata are among the most slow-growing of all tumours; hence, too, they sometimes attain a considerable size. That they are capable, to some extent at least, of undergoing retrograde changes, is shown by the frequent occurrence of fatty degeneration in their interior; but it is more correct to see in these indications of degenerative change, not so much a prospect of recovery, as an imminent risk of apoplexy, which threatens the patient's life as soon as the absorption of the fatty *débris* lowers the tension and removes the pressure upon the vessels in the interior of the tumour.

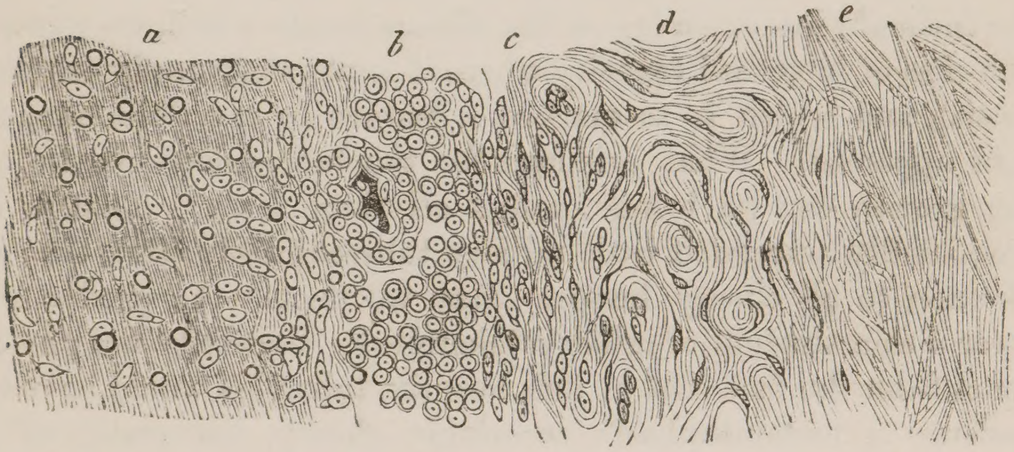
§ 744. MYXOMATA of the nervous matter ought to be considered from very much the same point of view as gliomata. Myxoma, in contrast to glioma, is more common in the spinal cord than in the brain, and more common in the peripheral nerves than in the cord. This may depend on some difference in the neuroglia, some slight modification in the parent-soil of the growth. Myxoma replaces glioma in the peripheral parts of the nervous system. In origin and growth they are alike. Myxoma sets out from an overgrowth of the nerve-cement, the perineurium; it extends uniformly in all directions by infiltration. The fibrous bundles of the cord or the peripheric nerves are pushed asunder and partly destroyed. In the nerves, myxoma forms spindle-shaped enlargements—NEUROMATA in the broader sense of the word.

Following *Virchow*, we draw a sharp line of distinction between true and false neuromata. The outward form is the same in both; a nodular or fusiform swelling of a peripheral nerve-trunk. But true neuroma consists chiefly of newly-formed nerve-fibres, while false neuromata are produced by a local proliferation of the interstitial connective tissue. This interstitial proliferation most commonly presents a fibroid character; more rarely that of a myxoma or of the softer, lipomatous variety of sarcoma.

§ 745. Finally, what is known as SOLITARY TUBERCLE of the brain must also be regarded as a product of the *neuroglia cerebri*. These yellowish-white, extremely tough and dry, cheesy nodules are more common than all the above-enumerated tumours of the neuroglia put together; they are met with in all parts of the brain and cord, either really alone, and then usually of considerable size—or in several smaller nodules, disseminated through the organ. Their favourite seat is in the cortical substance of the cerebrum and cerebellum, where they are developed close upon the cortico-medullary boundary. They are characterised by a singularly uniform rate of growth, extending in all directions with equal rapidity; hence, so long as they do not meet with any one-sided obstacle to their advance, they continue globular. Caseation begins at their centre before they reach any great size. The smallest tubercle I have ever seen, was made up of an aggregate of from three to six nodules no bigger than a pin's head, but already cheesy. The parts which have once undergone this change, either remain quite stationary, or earthy salts may, though rarely, be deposited in them; the latter change, of course, excluding all possibility of further metamorphosis. This stiffening of the formed parts of the tumour contrasts strikingly with the incessant growth going on at its periphery. We seldom find a nodule which seems to have completed its term of existence. It is usually surrounded by a soft, reddish-grey, vascular layer, which contains the formative elements of the tumour in the shape of an embryonic tissue rich in nucleated round-cells. The thickness of this layer is inversely proportionate to the size of the tubercle. In nodules as big as a pea, it averages a good line in thickness; in those as big as a pigeon's egg, barely half a line. The tissue is continuous with the cheesy nodule on one side, with the healthy brain-matter on the other. To obtain an insight into the finer anatomy of the growth and its secondary metamorphoses, we must therefore make vertical sections which include the unaltered brain-matter, the grey layer of embryonic tissue, and the cheesy substance. This can only be done by carefully hardening the specimen in *Müller's* fluid and alcohol. What do these sections tell us? They show that we are not justified in summarily regarding all solitary tubercles as identical with one another; that we ought, on the contrary, to recognise two distinct varieties, extraordinarily like each other in their coarser aspect—*sc.* a truly tuberculous and a non-tuberculous species of the solitary cheesy nodule.

§ 746. Let us begin by considering a vertical section through the edge of a non-tuberculous cheesy nodule as big as a walnut, taken from the cerebellum (fig. 202). At *b* we see the layer of round-celled embryonic tissue—at once the matrix of the tumour (*c*, *d*, *e*) and the product of the cerebral substance (*a*). It includes a divided vessel of some size, whose walls have fallen together, and whose adventitia is abundantly infiltrated with cells. No specific characters, nothing peculiarly tuberculous, can be detected in the embryonic tissue. If we turn our eyes to the left in order to trace the origin of the embryonic layer, all we can discover is that the corpuscular elements in the nervous matter increase steadily in number as we approach the zone of proliferation. We see them forming little groups of two, four, or more elements—an appearance which would formerly have sufficed to make us regard them as products of the proliferation of the neuroglia-cells. This simple interpretation has been denied us since the adoption of *Cohnheim's* migration-theory, and we are now forced to ask ourselves—especially in view of the vascular wall, so thickly infiltrated with round-cells—whether a transmigration of leucocytes from the blood may not be at the root of the whole formative process?

FIG. 202.



Solitary cheesy nodule (so-called "tubercle" of the brain). *a*. Normal brain-substance, medulla; *b*. Embryonic tissue of the zone of proliferation, enclosing a thickened vessel; *c*, *d*, *e*. Fibroid metamorphosis of the embryonic tissue, forming the marginal zone of the cheesy nodule. $\frac{1}{300}$.

On the opposite side of the embryonic zone, the appearances are less ambiguous. At *c* begins the transformation of the embryonic tissue into cheesy matter. How does this occur? In the face of the appearances figured above, we can hardly attempt to retain our ordinary notions of caseation (§ 33). We look in vain for a fatty-granular metamorphosis of the embryonic tissue, for the shrunken cells—the tubercle-corpuscles of *Lebert.* The only thing which recals fatty degeneration is a tolerably dense, finely-granular dust, which masks the oldest parts of the tumour (*e*), without leaving us in doubt for one moment that the texture is made up, not of cells, but of fibres only. The development of fibres between the corpuscular elements of the embryonic tissue (*c*), is clearly the change which converts the soft embryonic tissue into the hard tubercle. But the growth of fibres, and the condensation, predominate so enormously over the corpuscular structure, even at the very edge of the tumour (*d*), that we may unhesitatingly call the tissue "fibromatous." Even the intimate interweaving of the fibrous bands, which we regard as a sign of increased tenacity where it is physiologically present (cutis), and which is so marked a feature in the fibromata, is here apparent. What evidence for the tuberculous nature of the growth can we bring against all these facts? That it is occasionally associated with miliary tuberculosis? But that is common to all cheesy lumps. May we regard the productive layer *b* as a stratum of miliary tubercles? Certainly not; even apart from the fact that in this case the tubercles would have to undergo a metamorphosis, seemingly cheesy, but really of a fibrous character.

From all this I conclude, that there are "solitary tubercles" of the brain and spinal cord, which deserve rather to be called fibroid tumours. Granting this, we have a very satisfactory agreement between the neuroglia-tumours and the sarcomata generally; we may even recognise in the former the well-known fibrous and cellular forms of the sarcomata, modified by their place of origin, and the parent-soil from which they spring.

§ 747. On the other hand, we find small cheesy nodules, usually multiple, which prove on minute examination to be really tuberculous. Even with the naked eye, we can see that the grey zone of proliferation which surrounds them is not of a uniform texture, but consists of spherical nodules, each of which corresponds in shape and size to a miliary tubercle. If we shell out the central cheesy lump, we see that even *its* surface is beset with roundish elevations and protuberances. The cheesy nodule is accordingly made up of dead, the proliferating zone of living, miliary tubercles; and this view is thoroughly corroborated by microscopic analysis. The whole process is a *Phthisis tuberculosa* of the brain, entirely analogous to the destruction of the kidneys by localised miliary tuberculosis, &c.

DISSEMINATED TUBERCULOSIS of the nervous system has already been described under the head of Leptomeningitis (§ 697).

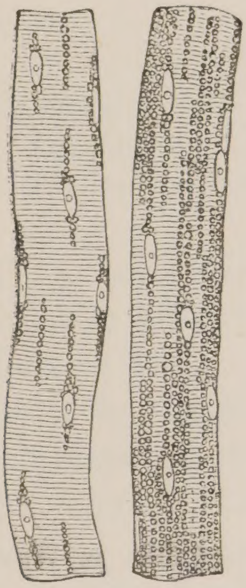
XVIII.—MORBID ANATOMY OF THE MUSCULAR SYSTEM.

§ 748. The two chief constituents of voluntary muscle, *sc.* striped fibres and connective tissue, differ in their liability to be primarily affected by the various morbid changes to which the muscle as a whole is subject. I say "primarily," for it is often in the earliest beginnings of a process only, that it is exclusively confined to the muscular fibrillæ or to the connective tissue; the mischief tending very quickly to spread to the other constituents also. In certain cases indeed, we shall find it quite impossible to decide whether the morbid change has begun in the connective tissue or in the primitive fibres; I prefer accordingly to follow the customary clinical arrangement of the subjects, instead of grouping them on a strictly anatomical principle.

1. Atrophy and Hypertrophy.

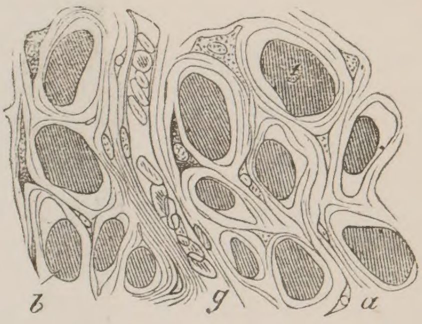
§ 749. The brown variety of atrophy, with which we became acquainted in the heart, as a consequence of progressive impairment of the general nutrition of the body (senile marasmus, cachexiæ), is never met with in the voluntary muscles. Fatty degeneration, too, is very rare (fig. 203), save as a result of parenchymatous swelling (§ 36). *Förster* refers PROGRESSIVE MUSCULAR ATROPHY, which gradually involves a variable number of muscles, to a fatty degeneration of the muscular fibres. Of greater moment as regards the voluntary muscles is SIMPLE ATROPHY, and that which is complicated with an interstitial development of fatty matter. This disorder nearly always affects such muscles as are kept in forced repose for long periods of time, as *e.g.* the flexors and extensors of an ankylosed joint, paralysed muscles, &c. Simple atrophy manifests itself by a shrinking of the individual fibres. On examining a transverse section of the wasted muscle, we may perhaps fail to discover a single fibre which still fills up the space allotted to it. The contractile substance separates from the sarcolemma, which remains in connexion with the interstitial connective tissue. It forms a loose sac, which it is more and more difficult to isolate in proportion to the length of time the disease has lasted; for it blends with the connective tissue, whose bulk it actually serves to increase. The corpuscular elements, too, of the interstitial tissue appear to contain more than their usual amount of protoplasm (fig. 204), and are well suited to convince an unbeliever, if such there be, of the existence and vitality of the intermuscular connective-tissue corpuscles. In the vast majority of cases, these cells undergo a complementary infiltration with oil; they are converted into fat-cells. This combination of atrophy of the muscular fibres with fatty infiltration of the connective tissue, furnishes a very beautiful set of appearances. Fig. 205 represents them in longitudinal section. The fat-cells, of uniform average size, are arranged in rows, which, lying parallel with those muscular fibres which still remain, seem each to replace

FIG. 203.



Muscular fibres in a state of fatty degeneration. $\frac{1}{500}$.

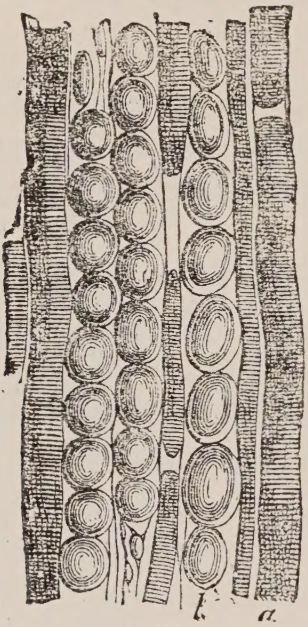
FIG. 204.



Simple atrophy of muscle. *a.* Interstitial connective tissue with large corpuscles; *b.* Muscular fibres in various stages of atrophy; *g.* Capillary vessel containing blood. $\frac{1}{300}$.

an obliterated fibre. It need hardly be said that this appearance is purely accidental. The figure also includes a fibre whose contractile substance has already given way at several points; its deficiency at these points enables us to trace the sarcolemma as an empty tube from one fragment to another; there is no trace of oily matter to be seen in the interior of the tube.

FIG. 205.

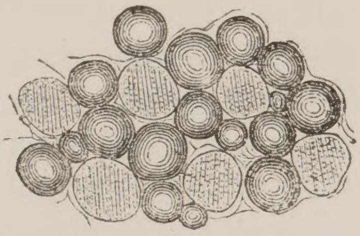


Simple atrophy with interstitial development of fat. *a.* Wasted muscular fibres; *b.* The rows of interstitial fat-cells running parallel to the fibres. $\frac{1}{300}$.

A precisely similar substitution of adipose tissue for obsolete muscular fibres takes place in the muscles of animals which are being fattened; in this case, however, the deposit of fat in the interstitial connective tissue is the primary phenomenon, while the disappearance of the fibres, though it may be partly due to the want of exercise, is really secondary.

§ 750. Another step brings us to SPURIOUS HYPERTROPHY of the muscles, which has lately been attracting renewed attention. Single muscles, or whole groups of muscles, swell within the period of a few months; but the swelling is so uniform that their anatomical form is maintained, though on a larger scale. This seeming hypertrophy is not, however, attended by any increase of functional power; on the contrary, the muscles grow steadily weaker, and are at length quasi-paralysed. On examination, they are found to be saturated with oily matter; the fibres are not wasted, but merely held asunder. Not one of them is in contact with its neighbours; they are held apart by a row of interstitial fat-cells (fig. 206).

FIG. 206.



Transverse section through a muscle in a state of spurious hypertrophy. The unaltered fibres are separated from one another by an interstitial development of fat-cells. $\frac{1}{300}$.

§ 751. TRUE HYPERTROPHY is strikingly exemplified only by the muscular substance of the heart, and has already been fully described (§ 235). There can be no doubt that the voluntary muscles of the trunk and extremities gain both in size and power through exercise; yet it is hardly possible, with the means now at our command, to demonstrate this hypertrophy anatomically.

2. INFLAMMATION.

§ 752. Inflammation of the muscles (*Myositis*) may be either acute or chronic. The acute form begins with parenchymatous swelling, and passes into suppuration and abscess; the chronic variety is due to long-continued or often repeated hyperæmia (rheumatism, repeated mechanical irritation), and passes into overgrowth of the interstitial connective tissue, fibroid and osseous metamorphosis. The contrast is the same as that between acute and chronic inflammation of the liver, and seemingly recurs in all the inflammations of parenchymatous organs.

§ 753. ACUTE MYOSITIS admits of being investigated to most advantage—as regards its earlier stages—in embolic, thrombotic and apoplectic conditions of the larger muscles. The first and chief factor in the process is a parenchymatous swelling of the muscular fibres. I have already described this as it presents itself in the muscular substance of the heart (§ 240); but I find that my description was too narrow to embrace the manifold variety of the phenomena as they occur in the voluntary muscles. The granular cloudiness is often subordinated to a peculiar change in the contractile substance which renders it at once more homogeneous and more bulky. The nuclei become invisible; the transverse striæ disappear. These changes, however, do not always affect the whole length of the fibre equally, they are more often limited to small portions of it; unstriped, swollen, almost glassy tracts alternating with others which are relatively normal. The segmentation of the fibre, so often seen and described, by transverse fissures recurring at brief intervals, makes these differences all the more apparent. The entire phenomenon gives one the impression that the distinction between the more and the less highly refracting, the more and the less dense substance of the fibres, is being effaced; as though the "sarcous elements" were swollen and dissolved, combining with their cement to form a homogeneous mass of glassy lustre.

In typhous myositis, where parenchymatous swelling of the muscular fasciculi also plays some part, we shall have an opportunity of acquainting ourselves with a further metamorphosis, termed by *Zenker* "waxy"; this is directly continuous with the stage we are now considering. In the common form of acute myositis the speedy onset of suppuration in the interstitial connective tissue makes it hard to trace the further course of the morbid changes in the fibres themselves. I have most frequently observed fatty degeneration of the inflamed fasciculi; and it also seemed to me as though their rapid loss of bulk were in some way related to the production of pus-corpuscles within the sarcolemma —as if the substance of the muscular fibre were used up by the pus-cells in the exuberance of their development. Of course, this cannot actually be seen; still less, however, can one resist the inference I have just suggested, when observing this simultaneous growth of pus-cells and diminution of muscular substance; and I see no reason why the hypothesis should not be recorded as such.

The pus-cells, which speedily accumulate in large numbers and form an abscess, originate therefore, according to the view which has hitherto been received, by proliferation of the corpuscular elements of the interstitial connective tissue; some part them are the progeny of the so-called muscle-corpuscles, *i.e.* of those scattered nucleated remnants of the embryonic cells from which the muscular fibre was originally developed, and which are left sticking to the inner surface of the sarcolemma (*C. O. Weber*). The bellies of entire muscles, *e.g.* of the psoas, may be converted into pus; more commonly, however, the abscess is limited to a spot varying in size from a pea to a walnut, according to the cause in each particular case. In myositis from embolism the inflammation barely oversteps the limits of the plugged area. The sequestration and expulsion of the pus, followed by repair—or the resolution of the morbid process, should the latter occur—ensue according to the known laws of healing by the second intention.

§ 754. CHRONIC MYOSITIS runs its course without suppuration, unless this should intervene accidentally. While in acute myositis a certain degree of anæmia goes hand in hand, at any rate, with the parenchymatous swelling, or is perhaps caused by it—hyperæmia takes up a far longer prodromal stage in chronic myositis. Rheumatic inflammation of the muscles does not usually leave permanent vestiges of its presence till it has recurred again and again, during a period of years, in the same muscle; so, too, in the production of the "manual exercise" and "cavalry" bones, it is only the incessant renewal of traumatic congestion which ultimately leads to the development of the ossifying blastema.

Chronic myositis, when once it gets beyond the stage of hyperæmia, manifests itself primarily in the development of an interstitial embryonic tissue. The muscular fibres take no part whatever in the process; the only question is whether the embryonic cells are derived solely from the corpuscular elements of the interstitial tissue, or whether they may not in part be emigrant leucocytes. Here, as in so many other forms of chronic inflammation, we are able to prove that the sheaths of the vessels are much thickened, and that this thickening is due to their being infiltrated with round-cells. As regards the interstitial embryonic tissue itself—the "exudation" of authors—it cannot be distinguished in any respect from the ordinary type; it is of a reddish-grey colour, permeated by newly-formed capillaries, and spontaneously disposed to undergo further metamorphosis in any direction. It usually becomes organised into a tough, dense connective tissue. The development of a "fibroid patch" is especially characteristic of rheumatic inflammation. In the interior of this patch the muscular fibres wholly disappear, and nothing is ultimately left beyond a narrow, ribbon-like strip, which represents the entire belly of the former muscle.

The same series of changes (I may remark by the way) occurs during the union of the divided surfaces, when a wound has broken the continuity of the muscle. A regeneration of muscular fibres in the cicatrix has been vainly looked for; observers having been repeatedly misled by the appearance of the spindle-shaped cells which are normally present in one stage of the healing process.

§ 755. Ossifying myositis (*M. ossificans*) is merely a variety of the chronic form. It underlies the two pathological curiosities above alluded to, *sc.* the "manual-exercise bone" of the deltoid, and the "cavalry bone" of the adductors of the thigh; it is also met with as a constitutional disorder, affecting several muscles at once, first in the back and afterwards in other parts of the body also. The embryonic tissue passes directly into compact bone-tissue. The "manual-exercise bone" is usually a three-cornered ossification, developed in the substance of the left deltoid near its tendinous insertion; by concentric apposition of new bone, it may reach an average length of 3 to 5 inches, a width of from 1 to 2 inches, and a circumference of from 4 to 5 inches. In the old drill of the Prussian army, there used to be a very favourite movement, in which the barrel of the musket was clapped against the spot in question with great force. The "cavalry bones" in the adductors of the thigh originate in the same way. We have recently been favoured with an interesting essay by *Münchmeyer* on *Myositis ossificans multiplex progressiva;* he establishes the histological fact that the disease depends on a true ossification of the interstitial exudation.

A simple deposit of calcareous matter may take place in the primitive fasciculi of the voluntary muscles; this must not be confounded with ossifying myositis. It is a mere pathological curiosity, and takes a very modest place in comparison with the terrible deformities of the muscular system to which ossifying myositis may give rise.

3. TYPHUS (ENTERIC FEVER).

§ 756. Pathologists had long known that abscesses in the muscles were occasionally met with in *Typhus abdominalis;* but *Zenker's* beautiful researches, which opened out a new path in this direction, first taught us that the *myositis typhosa,* to which these abscesses are due, was far from being rare. This variety of myositis chiefly affects the adductor group of muscles on the inner side of the thigh. There, amid muscles otherwise healthy, we come upon a circumscribed patch, from 1 to 3 inches in diameter, distinguished either by the coarser fasciculi being swollen, pale, and waxy, or by its being softened into a reddish pulp—the entire mass presenting a superficial resemblance to a muscular abscess.

The textural alterations which underlie these coarser abnormalities are among the most interesting in the whole domain of pathological histology. We are able to distinguish three processes, which go on together, and every one of which originates and runs its entire course in one of the several constituents of the muscle. Each forms an independent series, while they all co-operate in the task of destruction and renewal which is taking place.

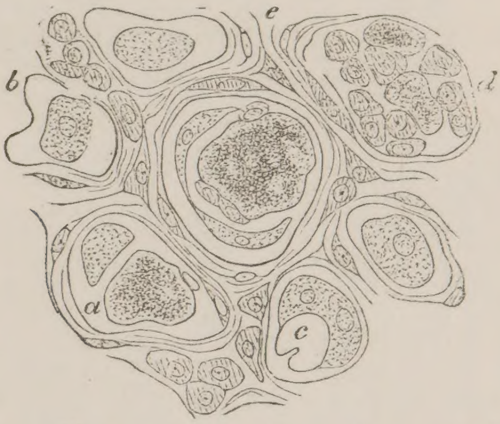
§ 757. Let us first of all consider that factor which may, and in my opinion, must be viewed as specifically "typhous." I refer to the corpuscular infiltration of the interstitial connective tissue. In treating of *typhus abdominalis* (§ 112, *et seqq.*) I found myself obliged to admit that the morbid process culminated in the production of a cell-form, which decidedly outran the ordinary pus-corpuscle in the degree of its individual development. The "typhous cells" indeed, are comparatively small, uninuclear elements; yet they contain more protoplasm, and are so far bigger than lymph and pus-corpuscles, white blood-corpuscles, &c. Crowded into a confined space, they assume an irregular, often quite polygonal form, and begin to remind the observer of epithelial cells. But degenerative changes speedily set in, and the cells break up, mostly by fatty metamorphosis, into oily *débris* capable of reabsorption. The same sort of cell recurs in those medullary infiltrations caused by *T. abdominalis* in organs not primarily involved, *e.g.* on the pleural surface; and we undoubtedly find it in the interstitial infiltration of the muscles. The striking dimensions and polymorphism of the "pus-corpuscles" figured in the annexed drawing (fig. 208, *c*) between the muscular fibres, must not therefore be viewed as a graphic error. Nay, I regard the interstitial products, whether they result from a proliferation of the connective-tissue corpuscles, or consist of migratory cells, as identical with the medullary infiltration of other organs, even though the naked-eye appearances are not the same, owing to the difference in the associated elements of the parenchyma.

§ 758. The relation in which the corpuscular infiltration of the connective tissue stands towards the changes in the muscular fibres cannot as yet be precisely formulated. *Waldeyer* has called attention to fibres which are wholly enveloped in young cells, nay, which appear to have been actually converted into such cells. This would oblige us to assume, either that these cells had immigrated into the tube of sarcolemma, or that the muscle-corpuscles upon its inner surface had, at least in part, undergone a proliferation identical with that of the connective tissue. I say expressly "in part," for they are mainly held in reserve for the work of regenerating the muscular fibres, after the great bulk of these, *sc.* of their contractile substance, has been gradually but completely destroyed.

§ 759. This brings us to the changes in the muscular fibre itself. It is clear, from what has just been said, that the behaviour of the contractile substance has to be strictly distinguished from that of the muscle-corpuscles. The contractile substance passes directly from a state of parenchymatous swelling into that of waxy metamorphosis (*Zenker*). Indeed the oblong fragments into which the contractile matter is broken up, are characterised by a very striking, though soft, waxy lustre; and the comparison with wax is rendered all the more apt by their melting visibly from their edges to their centre; their angles are blunted; they accommodate themselves to the structural elements which claim a place beside them (fig. 207, *a*). A fatty-granular cloudiness of the muscular substance has hardly ever been observed; the fragments usually grow smaller and smaller and finally disappear, retaining their lustre and waxy consistency to the last. With regard to this part of the process, a most gratifying unanimity prevails among observers. Not so with the third stage, the regeneration of the fibres.

I am well aware that I differ from many authors, and particularly from the meritorious *Zenker*, in ascribing the regeneration of the affected fibres to the activity of the pre-existing corpuscles contained in the tubes of sarcolemma. I do this only because my convictions on the subject are very firm. Transverse sections (fig. 207) are better adapted than longitudinal ones or specimens teazed out with needles, for showing that the new fibres are developed inside, and not between the tubes of sarcolemma. These new fibres, just as in normal development, present themselves in the form of elongated, fusiform and ribbon-shaped elements, furnished with a finely-granular protoplasm, and a large number of minute, vesicular nuclei; the latter being arranged in longitudinal rows of from two to twenty each (fig. 208, *b*). These cells adapt themselves to the space at their disposal; they begin by forming narrow bands, crescentic in transverse section (fig. 207), and closely ad-

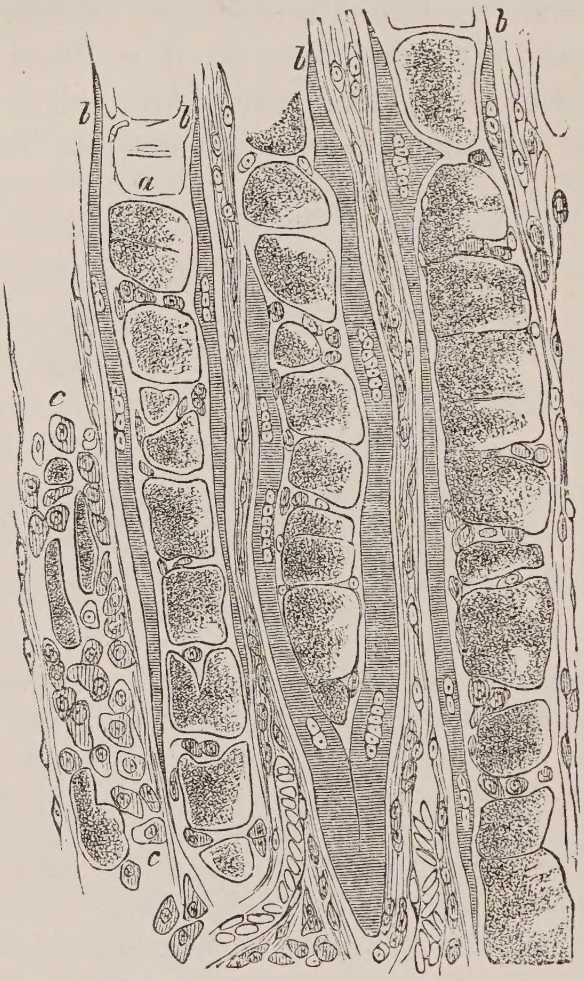
FIG. 207.



Myositis typhosa. Transverse section. $\frac{1}{500}$. *a.* Contractile substance in a state of waxy degeneration. Next it are seen the cells destined for its renewal, which are crescentic in transverse section ; *b.* A tube of sarcolemma with a young fibre, circular in transverse section ; *c.* Another, with a young fibre which is still semilunar in transverse section, and encloses a gap which might have contained a last remnant of the substance undergoing degeneration ; *d.* Another, containing a number of typhous cells, together with the remains of the old fibre ; *e.* Interstitial connective tissue infiltrated with typhous cells.

herent to the hitherto little-damaged cylinder of contractile substance; when the cylinder is broken up, and transverse clefts appear between the melting fragments, the protoplasm of the growing fibres forces its way into these interstices; the fibres thus appearing to be studded with conical projections. Transverse sections also show how the old muscular fibres as they shrink and the young ones as they grow, share the space afforded by the cylindrical tube of sarcolemma between them.

FIG. 208.



Myositis typhosa. Fibres seen lengthwise; specimen prepared partly by section, partly by teazing with needles. *a.* The waxy contractile substance of the old muscular fibres; *b.* The young fibres. (The shading by transverse lines instead of dots is merely for the convenience of the engraver, and must not be taken to denote the presence of transverse striæ at this early stage.) *c.* Tube of sarcolemma containing a very large number of typhous cells together with slender remnants of the contractile substance. The interstitial connective tissue richly infiltrated with cells. $\frac{1}{500}$.

The former look like rounded lumps, while the latter are crescentic, embracing and finally enclosing the former. As a rule, each tube of sarcolemma contains only one new fibre; it may, however, contain several. In the latter event, they coalesce with one another both transversely and longitudinally without any difficulty. The last remnant of the old muscular substance finally disappears, and a single new fibre, produced by the fusion of several corpuscles, takes its place. This grows bigger, and assumes a transverse striation; the nuclei distribute themselves uniformly upon its surface, and the new fibre is complete.

In the meantime, before the restoration of the fibre has reached completion, the infiltrated round-cells become fatty and are re-absorbed. The myositis typhosa subsides, like the medullary infiltration of all except superficial parts, without leaving any vestige of its presence behind it.

4. CANCER.

§ 760. The primary occurrence of very soft medullary sarcomata in the muscles (§ 761) has probably led to their being confounded with soft cancer; we may say broadly, that independent cancerous tumours in the muscles are always metastatic; they take the form of nodules of various sizes. Of course muscular tissue may be invaded by such cancers as extend by continuity of tissue. Epithelioma of the lip involves the labial muscles, cancer of the tongue is propagated to the lingual muscles, cancer of the optic bulb may infiltrate the muscles of the orbit. In every one of these cases, it has been clearly shown that the behaviour of the muscular tissue is, in the main, passive. Cancer of muscle is essentially an interstitial infiltration which separates the muscular fibres from one another, causing them to waste and finally to disappear. This is unconditionally true of the contractile cylinders. Doubts may arise as to how far the muscle-corpuscles or cells of the sarcolemma may participate in the morbid growth. That they *may* do so in every form of cancer, can hardly be disputed by any one who studies the drawings given by *C. O. Weber* in Virchow's Archiv, xxxix. Plate V. Whole nests of cells are seen to be developed *in the* *interior of the muscular fibres*, in cases where an epithelioma extends to the labial muscles, or a scirrhus of the breast to the pectoralis major. On the other hand, we must remember that this phenomenon is by no means constant. In all the cases of soft cancer of the muscles which I have personally investigated, I have been able to assure myself that the muscle-corpuscles in the wasting fibres remained inactive. The precise range of *Weber's* observations must therefore be left undecided for the present.

5. SARCOMA.

§ 761. Sarcoma of the muscles is also an interstitial growth. This fact has lately been established by *C. O. Weber* in a case of Gliosarcoma of the crural nerve which had invaded the Sartorius. As regards the soft sarcomata, which occur as primary tumours in the muscles, I would beg the reader to notice the state of the perivascular sheaths. I do not mean to say that the tumour originates in them; but within and immediately around them it exhibits a peculiar tendency to vary. For instance, in a sarcoma of the deltoid, consisting throughout of round-cells, I noticed sharply circumscribed areolæ round the vessels, within which the sarcoma presented a large-celled structure, and even contained a few giant-cells. This sarcoma recurred for years after its extirpation, and proved fatal at last by metastasis.

The occasional occurrence of cavernous tumours in the muscles has been fully discussed in § 129, *et seqq.* All other histioid tumours—fibroids, lipomata, myxomata, enchondromata—are but rarely met with in the muscles; in any case, they do not belong to the muscular tissue as such, but are developed in the intrafascicular layers of connective tissue.

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